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EDITORIAL NOTES

STEEL PRIORITIES

MUCH has happened in the eight months since the rationing of steel and cast iron for the various industries superseded the licensing system originally adopted on the outbreak of war, and allocations that were deemed to be reasonable in April bear little or no relation to the needs of December. At that time there had been no intensive enemy air raids over Great Britain, and the Gas Industry was carrying on, despite a thousand and one handicaps, almost at peacetime levels, maintaining all its public services and providing fuel for the war industries with an infallibility that seemed unshakable. But in the last three months holders have been damaged and mains fractured. There have been some interruptions in supply, and if public morale had depended on nothing more enduring than the working man's cup of tea and kipper we might have had some uneasy times since autumn set in.

What *has* happened is that the Government circles upon whom the responsibilities for maintaining essential services have been placed have recognized the supreme need for keeping the Gas Industry going ; we should not be overstating the position if we said that they have at last agreed with us that an adequate gas supply is as vital to the country as a plentiful supply of pure water. The result is that for emergency repairs the Gas Industry, in Greater London at all events, is receiving a higher priority for its supplies of steel—a priority which bears a proper relation to the urgency of the work in hand. The undertakings on the one hand, and the contractors on the other, have got together to deal with the situation, and we believe they are satisfied that the best they can expect has been done for the Industry in all the circumstances. We have not yet been able to discover what is the corresponding position in the provinces, but it may be taken for granted that what has been done in London will ultimately be done throughout the country, for the tendency everywhere is to deal with raid damage on a national rather than a local scale.

This more urgent work is now taking proper precedence over the nicely worked-out system of distributing the available supplies of steel among the industrial units within the control of each of the 19 Government Departments responsible for authorizing supplies. Eight months ago the Gas Industry wondered whether it was getting its rightful place in the scale of national necessities when it was told that its steel supplies were to be allocated under the " B.T.I " symbol—and then only a percentage of its total pre-war needs. The Board of Trade had a host of other industries to look after, and it seemed odd that one great public utility should be included in a bunch of other industries, while other public utilities seemed to be much more in the front line. Let it be said at once that each separate division has done its best with the material at its disposal, and the Gas Industry has no quarrel with the way in which its allocation has been distributed. No one expects to get a quart out of a pint pot, but its difficulty has been that the priority for the Industry was not enough to enable it to discharge effectively the most important of its vital services to the nation and the community, and this applies particularly in the position with which it is faced to-day. While it may be impossible to indicate any hope of an increase in the supplies of metal for the more routine purposes, we do feel that now that the Gas Industry has been officially recognized as something that must be carried on at all costs, the rest of its requirements will be considered sympathetically. When all is said and done, a supply of gas with no means of turning it into useful heat is no good to anybody, and we may be assured, therefore, that so long as it can be shown that the finished article—be it a piece of gas-works plant, or an item of canteen equipment—is essential in the national interest, the necessary metal will be forthcoming. Where appliances are wanted for urgent national purposes, the materials are released with reasonable promptitude. As regards luxuries we fear there is no hope of getting any iron or steel, but we do not think anybody wants to buy luxuries these days, so that the problem solves itself.

HELPING THE COMMUNITY

IN the " JOURNAL " of July 10 of last year we said that the activities of the British Commercial Gas Association in connexion with the National Food Campaign launched at the beginning of April met with excellent backing from gas undertakings throughout the country. That was before intensified bombing of the country by the Nazis. Enemy aerial activity, however, has not deterred, but, rather, has amplified these co-operative efforts in many and varied directions. And in this work appliance firms having trained demonstrators on their staffs have continued to throw their weight into the Industry's collaborative effort. They have given, and continue to give, great service to undertakings by offering the assistance of their demonstrators. To give the Ministry of Food an accurate story of the work being done by the Gas Industry the B.C.G.A. requested a monthly return of demonstrations held, which demonstrations form part only of the co-operative activities. The response to this request has not been nearly as good as it could and should have been. From May to October only 144 gas undertakings made returns, so that it would be entirely wrong to gauge the extent of the work which the Gas Industry's Home Service is doing for the Government by ascertained figures of attendances at demonstrations. The picture would be woefully incomplete.

Demonstrations, as we have said, form part only—though a useful part—of the work being carried out by gas undertakings with the valuable assistance of the B.C.G.A., and a monthly résumé from undertakings of all types of work in connexion with the Food Campaign would be more useful. So let this be a New Year's resolution. We are sure that no one concerned with the Campaign is contemplating any slackening of effort. The reverse is, in fact, the case. Efforts are to be increased to achieve a far wider spread of knowledge on the problem of right feeding under wartime conditions, and we know of several interesting moves which are being made by gas undertakings. To itemize a few, there is the setting-up of advice bureaux, assistance to the poor by demonstration stalls in open markets, use of the travelling showroom in providing communal meals, home calls (in some cases meals being cooked in the housewives'

own kitchens), advice to those in reception areas regarding the catering for evacuees, help in enabling people from bombed areas to find accommodation elsewhere. The main theme of the Food Education Campaign is the same throughout the country, but the methods used to spread the doctrine to the public must fit in with local customs and be adaptable to the needs of the community under changing conditions. The Minister of Food recognizes this and does not attempt to organize the Campaign from London on hard and fast rules. Apart from formulating policy and assisting to carry it out, the Ministry encourages civic authorities to make their own plans for guiding all classes of their community in the best methods of using available foods. Gas undertakings, by co-operating with local education authorities and by adapting their own Home Service programmes to the Nation's present needs, are doing work of the greatest national importance, and at the same time are keeping their place in the public mind.

A WAR-MADE OPPORTUNITY

WAR conditions have imposed difficulties and restrictions upon the Gas Industry, to some of which we have referred from time to time. The Industry does not complain ; it sets about overcoming them, and it has done so with considerable success. War, too, has given the Industry new opportunities for service, to some of which no reference has, for obvious reasons, been permitted.

A recent example, the mention of which cannot possibly disclose useful information to the enemy, is a Regulation by the Minister of Labour and National Service, entitled the Factories (Canteens) Order, 1940. Under this it is laid down that the occupier of any factory in which more than 250 persons are employed, and in which is carried on the manufacture or repair of any munitions of war or of any materials, parts, or tools required for such manufacture or repair, or any work on behalf of the Crown shall, if so directed on behalf of the Minister by the Chief Inspector of Factories or by any other Inspector of Factories expressly authorized by the Minister to give directions under this Order, make arrangements to the satisfaction of the Inspector for the establishment and maintenance, in or in the immediate vicinity of the factory, of a suitable canteen attached to the factory or to a group of factories, where hot meals can be purchased by persons employed at the factory or factories.

We imagine that this Regulation is supplying a number of opportunities in many parts of the country for the Gas Industry, to which hot meals at any—or every—time of the day or night come alike.

"Fuel-Flue Gases"

As a result of our announcement on Nov. 20 that the American Gas Association had invited the "JOURNAL" to collect, and pass on to them British orders for copies of the new Handbook, we shall shortly be sending to America a first list of those who wish to possess this excellent work at the special " member price " of $2.50 which they have generously extended to our readers. Will any others who wish to order please *let us know at once*, so that we can cover as many copies as possible in one operation of exporting dollars and importing books—which is not without its special difficulties in these days.

We explained that we cannot quote an exact figure, since we must add any incidental costs, unassessable at the moment, in which we shall be involved for carriage, duty, &c. But through the generosity of the A.G.A., we on this side are offered a five-dollar book at half-price, and we can assure our readers it is an excellent risk. " Fuel-Flue Gases " was fully described and reviewed in our issue of Sept. 25, 1940, p. 535.

Situated almost in the heart of the ancient town of Poulton is a canteen which the people of Poulton have opened for the benefit of all the Services. It is heated by overhead gas radiators.

The Comforts Fund for the troops benefits to the extent of nearly £4 as a result of a whist drive attended by 78 members of the Burnley Women's Gas Council in the Burnley Corporation Gas Showrooms last week. The organizers were Mrs. A. F. Ames and Miss Lister.

Bolton Corporation Lighting Department have practically completed the installation of special war-time " starlight " street lamps. All main roads are lighted by this method, with one small exception, and there are over 1,300 " starlight " lamps now in the borough.

Personal

Mr. G. LE B. DIAMOND is relinquishing the position of General Manager to the Dover Gas Company upon appointment as General Manager to the Rochester, Chatham, and Gillingham Gas Company. Mr. Diamond is Engineer and General Manager of the Folkestone Gas Company and New Romney and Lydd Gas Companies, and has been associated with the Dover Gas Company for several years, and for the past three years as General Manager.

Mr. R. G. A. CLARK, the Engineer and Manager of the Company, assumes responsibility of the Dover undertaking.

Mr. Diamond's successor at Folkestone will be Mr. F. DAWSON, Manager of the Herne Bay Gas Company.

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At a recent meeting of the Accrington and District Gas Board Alderman JOHN BARLOW was re-elected Chairman for the ensuing year. Alderman Barlow has filled this position for 12 years.

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Mr. OSWALD T. LONGDEN, Assistant Manager of Musselburgh Gas Company, has been appointed Assistant Manager of Stirling Gas Light Company in succession to Mr. C. B. S. Mitchell, to commence when the latter takes up his appointment at Dunfermline. Mr. Longden received his training with West's Gas Improvement Company.

* * *

Mr. and Mrs. ROBERT M'NAIR, Benvue, Oswald Street, Falkirk, have celebrated their golden wedding. For 38 years Mr. M'Nair was Gas Manager at Linlithgow, retiring from this office seven years ago. Before going to Linlithgow he was Manager at Eyemouth for four years. One of his sons is Manager at Bicester, Oxon.

Obituary

Mr. JOHN WILLIAM TURNER, late Manager and Secretary to the Mirfield Gas Company, died on Dec. 15, in his 82nd year. He had been connected with the Company in various capacities for upwards of 60 years, and since 1906 until the date of his retirement in 1930 he had occupied the position of Manager and Secretary. He was also for some years a Director of the East Ardsley Gas Company, near Leeds.

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The sympathy of the Industry will be extended to Lieut.-Col. and Mrs. Sholto S. Ogilvie on the loss of their elder son, Flying Officer GLENCAIRN SHOLTO OGILVIE, who was killed last month during flying operations.

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The death occurred at his home at Hemel Hempstead on Dec. 13 of Mr. H. N. LIPSCOMB, A.M.Inst.C.E., whose retirement from the Watford and St. Albans Gas Company Board four months ago broke a long-standing family connexion with the local Gas Industry. Mr. Lipscomb became a Director in 1924 of the old St. Albans Company before the amalgamation with Watford, and his family had been connected with it since 1854, his father and brother having been Directors before him.

Non-Ferrous Metals Control

Commencing from Jan. 1 the following alterations are made to the arrangements set out in the Non-Ferrous Metal Control's circular letter of June 6.

The weight of copper and copper alloys to be used by any manufacturer in the production of the articles listed under paragraph (*b*) of that circular letter is to be restricted to 10% of the tonnage used by the manufacturer in the year ended June 30, 1939. These articles comprise : Gas water heaters of all types, wash boilers and washing machines.

This 10% quota is granted for Home Civil Trade. Requirements for export and for Government Departments should be applied for separately and will be considered on their merits. It should be noted that the definition " Government Departments " in this particular instance is to be taken to include not only the Service Departments, *i.e.* the Ministry of Supply, War Office, Admiralty and Air Ministry, but also all other Government Departments.

The tonnage of metal obtained by a manufacturer during any one quarter of a year must not exceed one quarter of the annual quota allowed on the above basis.

Apart from these alterations the other restrictions and conditions set out in the letter of June 6 still apply.

Manufacturers who adhere to the scheme set out in the circular letter of June 6, as amended in this letter, should quote the symbol " N.F.G. 1941 " when ordering from their suppliers, who must, in turn, quote this symbol on the schedules which they submit to the Non-Ferrous Metals Control.

Forthcoming Engagements

Jan.

14.—I.G.E.—Council Meeting.

14.—N.G.C.—Central Executive Board, 12.30 p.m.

14.—National Joint Industrial Council for the Gas Industry.—Meeting at Gas Industry House, 2.15 p.m.

THE COMBINED PRODUCTION OF GAS AND ELECTRICITY

By C. H. NOTON, *London and Counties Coke Association*

THE advantages of what is known as rationalization of industry are more frequently commercial than technical. For example, the ownership of coal mines by iron-smelting firms has as its principal object the ensuring of continuity of supply of coal for blast-furnace coke ; but also has as incidental advantages the possibility of the production of the exact quantities of coke required and the control of its quality. The securing of continuity of power supply also accounts for firms engaged in electro-chemistry frequently having large participations in the share capital of power stations. Few of these integrated concerns show a higher technical efficiency than would their components if operating independently. It is strange, therefore, that so little development of integration has taken place in a direction in which commercial expediency is accompanied by an increase in technical efficiency ; namely, the combined production of gas and electricity. In the whole of Europe there are not more than three jointly-operated gas and electricity works, and only one of these is other than small. There are, of course, numerous municipalities which run gas-works and power stations, but, so far from the plants being run jointly or the departments having a common administration, the two enterprises are managed quite separately, their only contact being in the nominal supervision exercised by the council of the municipality.

The commercial advantages to be gained by joint operation and administration include the following : Joint purchase of coal and all other consumable requirements, such as engineers' stores, with consequent reduction in price and improvement in suppliers' service due to larger orders. Joint transport of coal, ash, and other materials, whereby in one of the cases which will be given below a saving of 25% was made on the expenses of the two works when operating separately. Joint development of new areas and joint maintenance of existing distributing systems, with consequent very large savings, amounting in the case mentioned above to about 40% of the expenses incurred under independent operation. Joint reading of meters, and joint accounting and collection of cash, resulting again in a reduction of outside staff by 40%, and a considerable saving in book-keeping expenses, both in wages and materials.

The technical advantages are scarcely less numerous and certainly no less important. They merit extended discussion.

1. All electricity supply undertakings which cater for household or agricultural, as opposed to industrial consumers, have to contend with a high peak load which may be double their base load, but which, owing to its short-lasting imposition, may account for as little as 5% of total output over a year. The necessity of providing installed generating capacity equal to the normal base load in order to satisfy such a small total demand is a heavy economic burden, but a burden which must be borne except in those rare cases where pump-storage is a possibility—unless gas is called in. Electricity cannot be stored ; but gas *can*, and can therefore be applied to satisfy peak power loads. The power station that can call on the stored gas in a neighbouring gas-works to turn into power can avoid, at least in part, the installation of peak-load generating capacity by burning the gas under its boilers or in gas engines—or even, if courage accompanies commercial perspicacity, in a gas turbine. If the gas is burned under boilers already burning solid fuel, the installation of extra steam-generating capacity may possibly be avoided entirely ; while, if part of the peak load is taken up in this way and part by gas engines, the extra installation costs may be considerably reduced. The principle naturally has limitations ; the generation of 1 kWh. by a steam turbine requires about 35 cu.ft. of gas to provide the steam, so that a peak load of 5,000 kWh. would require roughly 175,000 cu.ft. of gas per hour, which is an amount which could be spared for a few hours daily by a works of about 1,000–1,500 million cu.ft. annual capacity. This size of gas-works counts as much bigger than a typical municipal power station with a peak load of 5,000 kWh. ; so that not all the peak load of a power station could be taken by an associated gas-works of equal thermal capacity. A further limitation is, of course, the price at which the gas can be sold to the electricity undertaking. This is strictly speaking a question of book-keeping, which, under joint operation, can be manipulated to show a suitable low price for gas into holder. In the case which appears first in what follows it was found that, if coal cost 25/- a ton as fired to boilers, the price of gas could not exceed 1½d. a therm—a low figure which speaks well for the efficiency of electricity generation.

2. The net output of all products of the gas-works can be controlled, first of all by selling all breeze and undersize coke to the power station, and, secondly, in times of increased demand for gas or coke, using surplus coke or gas for power generation. The first of these operations is, of course, not unfamiliar to the larger gas-works, which themselves burn their own breeze in their boilers ; but there must be many a smaller works which would welcome such a steady market for all its breeze—even though at a low price—as would be provided by an associated power station, which in turn would welcome a steady supply of low-priced fuel over the quality of which it would, under joint control of coal purchase, have some small measure of control. The second possibility mentioned above—that of balancing the output of the gas-works without varying recourse to water-gas production, steaming of retorts, and so on—has numerous advantages, such as, on the one hand, the avoiding of piling up large summer stocks of coke with consequent troubles due to degradation and occupation of space needed for stocking coal against winter requirements, and on the other hand, the elimination of the rarer difficulty of the obligatory manufacture of superfluous gas in order to satisfy an exaggerated demand for coke.

3. The possibility of providing, with the joint capital, a much larger and better-equipped workshop, with special machinery that would be beyond the purchasing power of the separate concerns. In addition, and connected with the provision of this workshop, the establishment of a body of specially trained workmen to deal with the kind of job that would usually require outside contractors to be called in.

4. The supply of the power requirements of the gas-works can be undertaken by the power station at a price that could not be approached by the gas-works even under the best conditions of utilization of waste heat. Here again, of course, a book-keeping adjustment will be required to free the current for the gas-works from the burden of overhead costs.

The best-known example of joint production of gas and electricity is the Municipal Works of Kiel. The annual capacities of the two works, which are situated side by side on the Nord-Ostsee canal, are 1,240 million cu.ft. of gas and 80 million kWh., so that their thermal capacities are of the same order of size. The method of joint operation is described in detail elsewhere :* it centres round a battery of specially-built Collin chamber ovens. This plant is fed with producer gas preheated in a coke dry cooling plant (one of the very few in Germany, and an essential part of the Kiel scheme) ; the flue gases pass at about 2000° F. to a high-pressure waste-heat boiler operating at 260 lb./sq.in. pressure and 660° F. All the steam from this boiler goes straight to the power station, whence it later returns at low pressure to be used in the gas-works. The remarkable figure of 1 lb. of steam per lb. of dry coal is achieved. It is at Kiel that the previously quoted savings in transport costs and outdoor staff were realized.

A less well-known example is that of the combined gas, electricity, and water works at Delmenhorst, near Bremen. This is a small town, where the three works are all small ; the annual capacities are 80 million cu.ft. of gas, 600,000 kWh. and 1,750,000 cu.ft. of water. Thermally, therefore, the gas-works and power station are of much the same size. The gas-making plant comprises two vertical chamber oven houses, one of five chambers, the other of six, each chamber having a capacity of 1.5 tons of coal. The works has a waste-heat boiler of 300 sq.ft. heating surface. There are benzole and ammonia recovery plants and a tar distillery. In the power station there are three high-speed steam engines of capacities 100, 150, and 250 h.p., and two suction-gas engines of 160 and 260 h.p., with arrangements for town gas firing if necessary. There is also a waste-heat boiler, of 350 sq.ft. heating surface, operating on the exhaust gases of the gas engines. In the water works there are two town gas engines, each of 35 h.p., for driving the pumps.

When the Delmenhorst power station was running with coal-fired steam boilers, slightly over 4 lb. of coal was used per kWh. generated, which represents an efficiency of 6%—a low figure, but not uncommonly low for a similar plant using steam engines

* Report No. 10 (in German, by T. Ploppa and others, in Vol. XI, Section 17, of *Proceedings of Second World Power Conference*.

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and not turbines. When the gas engines were installed and town gas or suction gas generated in coke-fed producers was used, the following much improved results were obtained :

	Per kWh.	*B.Th.U.*	*Efficiency.*
Suction gas	2.6 lb. coke	29,500	11.9%
Town gas	35 cu.ft.	19,000	18.0%

Even if suction gas were used almost exclusively, the increase in efficiency would very soon enable the installation costs of the gas engines and producers to be written off. This represents the commercial gain from the turnover ; but, from the technical point of view as concerns the power station, there remained the possibility of satisfying any likely increase in base or peak load by increasing storage capacity in the gas-works rather than by the much more expensive means of installing new boiler or engine capacity in the power station. From the gas-works point of view the technical gains were immediate, as the following analysis shows :

The gas-works required annually the following quantities of steam :

Tons.	*Purpose.*
200	Service hot water.
120	Water gas.
220	Benzole plant.
230	Ammonia plant.
1,300	Works steam engine.
15	Tar plant.
200	Heating gas holders.
450	Heating works buildings.
2,735	

The following quantities were available from sources in the gas-works and power station :

Tons.	*Source.*
1,000	Gas-works waste-heat boiler.
550	Power station waste-heat boiler.
1,330	Cooling water of gas engines.
2,880	

The 1,330 tons of steam shown above is the equivalent quantity of the very large volume of water at 105° F. obtained from the cooling system of the gas engines. It is introduced in this form only in order to show the steam balance of the gas-works, and is actually used on the works only to heat the holders, although it could, of course, be used for service hot water and as preheated feed water for the waste-heat boilers in either gas-works or power station. In point of fact it is pumped to a nearby swimming bath. The steam balance thus becomes :

	Required (tons).	*Available (tons).*
	2,735	2,880
Less	200 (holders)	1,330
	2,535	1,550

There is thus an annual deficit of 985 tons, which has to be made good in the gas-works by the combustion of one or other of its own products in the waste-heat boiler. According to the relative current demand for gas and coke, either of these is fired in the boiler ; and the total quantity of both involved to generate 985 tons of steam, being only about 15% of the thermal yield of the works, does not seriously affect the availability of either product. In exchange for the fuel required to produce the steam, the municipality receives 600,000 kWh. of power, which is thus in effect generated at the startling efficiency of 30%—higher than Battersea !

It will be seen that the gas-works and power station work hand in hand ; the water works also falls into the scheme in a small way. Under suitable conditions, however, the water works could be made to form an integral and very important part of the joint unit. One way of improving the load factor of power stations—that is, in other words, of reducing the financial burden imposed by peak loads—is by using power in off-peak periods to store potential energy in the form of water in an elevated reservoir, the water then being used to produce power by means of flow-turbines during peak load periods. There are several large stations of this kind in Europe, those at Herdecke in the Ruhr (130,000 kW.) and Niederwartha, near Dresden (70,000 kW.), being probably the best known. The principle involved is, however, one which is capable of application on almost any scale ; it might, for instance, be applied in a water works owned by a company which also owned a power station. The ideal circumstances for its application would naturally be in a hilly district, where the reservoir of the water works would be situated in a local elevated basin whence the water, having been pumped up while the load on the power station was low, would be used to generate power in peak periods while flowing down to its place of use. Even in a flat district the normally employed water-towers could be built on a scale larger than usual and could be used deliberately as sources of energy at any time, whether or not the water was needed for consumption. If it was not needed, it could once more be pumped up when the peak period had passed.

In the case of Kiel, the overall efficiency of utilization of the coal in the gas-works appears to be nearly 90%, and in the power station about 35% (taking into account in the latter case the free steam obtained from the gas-works). The efficiency of the combined unit is not known exactly, but would appear to be nearly 70%. At Delmenhorst the overall efficiency is naturally somewhat less. The load factor of the joint Kiel unit—that is, the energy produced in a year expressed as a percentage of the annual energy capacity—is nearly 75%, which is an astonishingly high figure. At Delmenhorst the load factor has been calculated to be even higher ; in one year it touched almost 80%. In either case, if it had been possible to make use of pump-storage, these high figures could have been improved.

The Clayton and Allied Firms

Sports Association Gathering

Under the Chairmanship of Mr. L. H. Riddell about 160 members and friends recently attended the Annual Dinner of the Sports Association connected with the firm of Clayton, Son & Co., Ltd., gas and constructional engineers, and its associate firms—Deighton's Patent Flue and Tube Co., Ltd., Goodall, Clayton & Co., Ltd., and Yorkshire Patent Steam Wagon Co., of Hunslet, Leeds.

The toast " The Allied Firms and the Sports Association " was proposed by Mr. I. Shuttleworth, President of the Leeds and District Cricket League, who congratulated the Sports Association on its sound organization, and mentioned the world-wide reputation gained by Claytons over the past 70 odd years, and the co-operation existing between the Directors and employees. The Chairman, responding to the toast, thanked Mr. Shuttleworth for his remarks, and pointed out the work done by the associated Companies. Mr. J. J. Baines (ex-Director) proposed the toast " The Guests," to which Mr. J. Clifton Town (Yorkshire County Cricket Club) responded. He praised the cricket section on their success during the past season.

The Honorary Treasurer of the Sports Association—Mr. J. Rathmell—reported the Association was very sound financially, although activities had been curtailed owing to existing conditions. Only the cricket and swimming sections had been able to carry on on anything like normal lines. The cricket section had been particularly successful, the first team having finished second in their first season in the senior division of the Leeds & District Cricket League, and the second team third in the reserve section of that League. Only one angling match had been held, for the " Hartley " Trophy, and the golf section had been unable to organize competitions for the " Clayton " and " Thomson " Trophies. The swimming section had been very successful, and trophies had been promised for competition next year.

The employees' field day, children's trip, and children's Christmas party, organized by the entertainment section, had all been cancelled, but as a slight recompense the children affected, numbering about 400, had received gifts both during the summer and at Christmas. A Reserve Fund was being built up for the entertainment of the children when times were normal, and also a fund for the building of a new pavilion or institute had been opened.

The trophies competed for, together with replicas and prizes, were presented to the winners by Mrs. Riddell.

An article in last week's " JOURNAL " by Mr. A. F. Ames dealt with the conversion of diesel engine passenger vehicles to fuel oil and gas at Burnley. Our photograph shows one of the converted vehicles.

TOLUOLE RECOVERY BY GAS-WORKS*

By P. T. DASHIELL, *Vice-President, The Philadelphia Gas Works Company.*

THE entry of the United States into a war would bring many problems to our Industry, the solution of which will be the duty of its technical men. In such case, the first and most important assignment will be the preservation of adequate gas service both to communities and industries now being served and to additional industrial operations which must spring up as part of the general National Defence Plan.

To my mind there is no more important objective for our Industry than to preserve the service and, by foresight and planning, to be prepared to furnish additional gas when and where it is needed. We had experience in the first World War of how great this additional demand may be and how suddenly it may occur. Many of us have not forgotten that experience.

Part of that preparedness is protection of the manufacturing plants and distribution systems from sabotage and wilful damage by persons who may be inclined for one reason or another to attempt to cripple certain industries, by striking at their fuel supply or to bring general confusion by destroying a public service which is vital to normal living.

There was little of this in our Industry in the last war. One good reason, perhaps, was because of the careful precautions taken against it. We should be no less prepared in this respect now and we have some experience to help us.

There is, however, a new danger in connexion with modern warfare with which we have had no experience in this country. Danger from air attack is one which we know little about first-hand. Protection from such involves a new technique which we may have to develop, profiting as far as we can by the experience of others in countries which have had, or are having the experience. In addition to anything we can get from this source, there must be a large amount of original thinking for ourselves. No two situations even in the same country are alike, and the best methods of procedure in each situation must be developed specifically for that one. My opinion of the best way to do that is as follows.

We have a Committee of the American Gas Association for National Defence made up of prominent and able men. There should be small sub-committees of the main committee charged with the study of the best methods of protecting against malicious attack from within, destruction from the air of vital portions of the plant, protection of operating personnel, &c.

Need for Security

To my mind it would be the height of folly to discuss in gatherings such as this, or in the technical publications, the best method of protecting this or that, for in such discussions or papers, the most important and perhaps most vulnerable part of the plant or distribution system is bound to be publicized and malicious persons, by reading the record of discussion or technical articles, will be informed as to when and how to strike.

The results of study by the sub-committees should be conveyed to a responsible officer of every gas company in the country confidentially, and the conditions of his company made a subject of specialized study. The full co-operation of the management of each company must be had.

The measures for protection should be taken with as much secrecy as possible. Even the fact that protective measures are being taken at all should receive a minimum of publicity.

I would like to emphasize again that I believe the details of all such procedure should be kept out of discussions at association meetings, and there should be no descriptive articles in the Technical Press.

Consideration must be given to the fact that under war conditions, the raw materials of gas manufacture, generator fuel, oil, and coal available to us, may change considerably in quality from present-day conditions. Study should be made as to how gas of required quality and quantity could be produced with raw materials of poorer quality or even of different character from those now in use. For instance :

At the last Production Conference, A. E. Pew, of the Sun Oil, gave us some very valuable information as to the availability of oil for manufacture of water gas.† Among other things he said that the more viscous and heavier refinery residues were of least value to the oil refineries and, therefore, could probably be had at lower price, if our Industry could use them.

Bunker oils are, in many cases, made by cutting back these heavy residues with cracked gas oil or cracking plant tar, to Bunker C viscosity. Ships must have bunker oil and require oil of Bunker C viscosity. The Navy particularly will insist that its oil must meet the specification of viscosity " Not over 300 Sec. at 122°F.—Saybolt Furol."

A heavy demand for bunker oil for the Navy may mean to us that a large portion of the materials now used by refineries in making oil for our use, of the viscosity which we desire, will not be available and we will, therefore, be compelled to use these heavy refinery residues with a minimum of fluxing. Fortunately many of these residues have a higher enriching value in carburetting water gas than the fluxing agents generally used. Their use in a water gas plant becomes simply a mechanical problem involving larger and better insulated tanks and pipelines, better heating equipment in tanks, and for secondary heating of the oil before it reaches the oil-spray.

Gas oil under war conditions will certainly be scarcer than at present, and, therefore, more plants will be driven to using oil of fuel oil type. Some study has already been made to find out what operating methods and changes in equipment are necessary to the successful use of these highly viscous oils for carburetting water gas. The results of such, as far as is known to the writer, are favourable.

Again, in case of scarcity of coke it may be necessary to use as generator fuel either anthracite or bituminous coal, with oils of high viscosity.

It has been demonstrated that some types of anthracite can be very successfully used in conjunction with heavy oil for water gas manufacture. Research work is now being carried further on the use of anthracite for generator fuel, but there are some serious problems connected with this which have not been solved as far as I know.

The combination of bituminous coal as generator fuel and heavy oil for carburetting is more difficult, and the difficulties involved have not been entirely solved, but at least we know that a fair percentage of prepared bituminous coal can be used in the generator of a water gas set along with coke when the carburetting is to be done with heavy oil.

Toluole Recovery

Our product—manufactured gas—in almost all cases, carburetted water gas or coal gas, contains chemicals which are of use in the manufacture of explosives, and other materials required by a nation at war. The work done in the last war, by the technical men of our Industry in the production of such materials, is well known, at least to the older men, some of whom are here to-day.(1)

One of the most important of these materials is toluole, the basis of the explosive trinitrotoluole. For the benefit of some of us who perhaps are not familiar with toluole, or the technique of its recovery, I will say that it exists as one of the hydrocarbon vapours of the aromatic class present in both water gas and coal gas, and can be recovered from the gas as one of the constituents of what is commonly called light oil, by one of several methods.

At the last Production Conference, a description of several methods of light oil recovery and of the design and operation of a light oil recovery plant was given in a Paper written by M. Tiddy and M. J. Miller, of Semet-Solvay Engineering Corporation.(2)* As I do not see how that Paper can be improved upon I will omit here any detailed description of such a plant and recommend the careful study of that Paper to anyone interested.

At the beginning of the first World War 1914 to 1916, the foreign governments, notably the French and Russian, were desperately short of toluole and would pay almost any price for it. They purchased large quantities in this country, and the by-product coke industry and the Gas Industry, to some extent, profited considerably thereby.

When the United States entered the War the demand for T.N.T. for our own Army and Navy exceeded anything that had ever been known before. At that time, as is the case to-day, the main and ready source of supply was the by-product coke industry. It had a potential production of about 8,000,000 gallons per year, with additional plants under construction, which upon completion, gave a production of 17,000,000 gallons in 1918.(3) The requirements of the Government were stated in 1917 to be 17,000,000 gallons per year, increasing in

* Presented before the Technical Section, American Gas Association, Annual Convention, 1940.

† *American Gas Journal*, June, 1940.

* *American Gas Journal*, September, 1940.

1918 to 27,500,000 gallons. The question was, from what source could the deficit be made up?

In that year, 1917, the general procedure was very similar to that of to-day. A Joint Committee of the gas and electrical industries was formed. Its services, offered to the United States Government Council of National Defence, were accepted. There was formed a Chemical Committee. A sub-committee of the latter, known as the Sub-Committee on Coal Tar By-Products, had in hand the recovery of toluole from gas-works. Its report,(4) published and copyrighted by the American Gas Institute, is interesting and instructive. It goes into great detail as to quantity of toluole available, method of recovery and equipment necessary. The fundamental data of that report are as good to-day as they were in 1917, although the type of equipment available to-day is superior to that of 1917. The gist of the report is that from gas-works then producing toluole the quantity available was 2,957,000 gallons per year, with the possibility of increasing that to 9,000,000 gallons by production from other companies.

The Position To-Day

A careful study(5) of conditions to-day indicates the following :

Toluole available from by-product coke industry 30,000,000 gallons per year.

From the Gas Industry certainly not more than in 1918, possibly less than 9,000,000 gallons. A recent investigation made by the Committee on National Defence of the American Gas Association indicates 9,560,000 gallons from 19 companies.

Possible requirements are more than three times that of 1917 —somewhere between 40,000,000 and 60,000,000 gallons. Where is the deficit to come from? The only source is the oil refining industry.

Toluole from an oil refinery was unheard of in 1917, but during the latter part of that year and in 1918 research work was done and one or more methods developed for toluole production directly from oil cracking. Since that time, the advancement in the art of oil cracking, and in the use of catalytic processes, has produced in the oil refining industry a tremendous potential for toluole production, but little if any toluole is being produced by it to-day. It seems, however, to be the only source from which the deficit, above referred to, can be made up.

Do what it will, the Gas Industry cannot even begin to bridge that gap. If our Industry in general goes into the business of toluole recovery, it will be for the purpose of doing its part in National Defence and not from the profit urge. I believe that this is also true of the oil-refining industry.

Both the potential sources of toluole—the Gas Industry relatively small, the oil-refining industry very large—larger even in potential than the by-product coke industry is to-day.

An important point is that neither the Gas Industry nor the oil refineries are ready to start production. The by-product coke industry is. Some units of the Gas Industry are in production now, but in most situations heavy construction work must be done requiring from six months to one year from date of starting before any toluole-bearing oil can be produced.

The condition in the oil industry is very similar. No units are in production at this date and six months to one year will be required to get them into production.

(*Business Week*—issue of August 10, 1940—refers to a plan by the Shell Oil to build at Houston, Texas, a toluole plant having a capacity of 2,000,000 gallons per year and over.)

All things considered, it is my opinion that the Gas Industry in general will not be called upon to produce any more toluole than can be produced by those few plants which are now scrubbing their gas for light oil, unless the country should become so deeply in need that the potential production of the by-products coke industry and oil-refining industry were to be entirely used up, a condition which seems at this time impossible.

It is possible, however, that, because in several situations much of the 1917–1918 equipment is available, and for that reason certain plants not now scrubbing their gas for light oil can be quickly got into production, these may be required to start scrubbing and produce at least a fraction of light oil rich in toluole, to be refined to nitration specifications at some nearby refining plant.

It is apparently true at this date that there are not enough refining plants nor enough nitration plants to refine or to nitrate more than half of the quantity of toluole taken as the ultimate goal of production.

It may be of interest to consider certain features of toluole production by gas companies, operating as public utilities, which are important and which account for the fact that they can probably produce to-day not more than they could have produced in 1917–1918, and why it is difficult for them to produce at a cost that would show a profit to their operators.

The reason that the Industry as a whole has not as great potential production as in 1917 and 1918 is that in so many large situations natural gas has entirely or in part been substituted for coal gas and carburetted water gas. No toluole can be had from natural gas. Much of the coal gas that was made by gas companies in retorts in those years has been replaced by coke oven gas purchased from the by-product coke industry stripped at the oven plant, and the toluole from that source has therefore been reduced as far as our Industry is concerned by transfer to another industry.

The consumption of oil used for carburetting water gas is less to-day than in 1917–1918 because many of the larger companies were operating on a candle-power standard then, whereas they now operate on calorific value standard, and to-day are selling a gas of lower calorific value than the gas had under the candle-power standard.

Under present-day conditions, as well as those of 1917–1918, there are certain additional costs beyond those of merely operating the scrubbing plant and stripping out light oil.

When light oil is scrubbed from gas, its calorific value is lowered by about 135,000 B.Th.U. per gallon of light oil removed per 1,000 cu.ft. or 135 B.Th.U. per cu.ft. of the gas.

To maintain the standard of calorific value required by state or city, these lost B.Th.U. must be restored ; or to put it another way, the unstripped gas must be made at such a calorific value that it can be partially stripped and still meet the requirements. This means additional cost.

Many water gas plants are now carburetting with heavy oil, of the fuel oil type, and with the present relation of oil price and that of generator fuel coke, it pays to " reform " as much of the oil as possible. Such practice is not favourable to maximum toluole production, and tends to increase the benzole content of the light oil.

For maximum toluole production there should be a minimum of " reforming " of the oil vapours. This will result in a decrease in consumption of carburetting oil per 1,000 cu.ft. for a gas of a given calorific value, an increase in generator fuel, a decrease in rate of gas production of the plant, a reduction in tar make, and a change in quality of the tar which may be favourable or unfavourable, depending upon the use to which the tar is put. (In general, the gravity and viscosity of the tar will be reduced and percentage of distillate will be increased.)

As an example : Assume that the heavy oil used for carburetting has an enriching value of 100,000 B.Th.U. per gallon and costs 3c. per gallon, generator fuel costs $8 per net ton, tar production is 25% of oil used on the set, that the boiler fuel value of the tar is based upon that of the original oil and that due to its greater weight per gallon, its value per gallon as fuel is 1.1 times that of the oil or 3.3c. per gallon dry basis, that the calorific value to be maintained is 535 B.Th.U. per cu.ft. Under the operating conditions established to produce a gas of 535 B.Th.U. calorific value at lower cost per 1,000 cu.ft. for oil and fuel, less tar credit, about 30% of the oil will be used on the backrun. Typical results will be :

Oil per 1,000 cu.ft.		4.50 gall.
Generator fuel per 1,000 cu.ft.		13 lb.
Tar production		1.125 gall. tar per 1,000 cu.ft.
Net cost of fuel and oil, less credit for tar, will be—		
4.50 gall. oil at 3c.	=	13.50c.
13 lb. Coke—gen. fuel	=	5.20
Gross cost—		18.70
Tar credit, 1.125 gall. tar at 3.3	=	3.71c
Less dehydration and recovery cost œ .5c. per gall. of tar	=	.56c
		3.15
Net cost		15.55

Under the above operating conditions the percentage of the carburetting oil recoverable as pure toluole will probably not be over 1.5% = 0.0675 gall. per 1,000 cu.ft. This can be increased to over 2% by cutting out the reforming as far as possible, admitting oil to carburetter and generator fire top during the up-run only, with a generous purge of the set before switching to the back-run.

Now assume that it has been decided to scrub from the gas 0.4 of a gallon of light oil per 1,000 cu.ft. or 10% of the carburetting oil used and to maintain the calorific value of the scrubbed gas at 535. The calorific value of the unscrubbed gas will have to be about 562, the generator fuel consumption will be about 21 lb. per 1,000 cu.ft., the oil consumption 4 gall. per 1,000 cu.ft., the tar production 1 gall. per 1,000 cu.ft.

The cost for fuel and oil less credit for tar will be—

4 gall. oil at 3c.	= 12. c.	
21 lb. fuel at $8 per ton	= 8.40	
		20.40
Credit for tar—1 gall. at 3.3c.	= 3.3c.	
Recovery and dehydration	= .5	
		2.80
Net cost per 1,000 cu.ft.		17.60

This shows an increased cost over that of operation with maximum reforming of 17.60c.—15.55c. = 2.05c. per 1,000 cu.ft.

Under this second set of conditions, when 10% of the carburetting oil—*i.e.*, 0.4 gall. per 1,000 cu.ft.—is to be scrubbed from the gas, there will be a reduction in calorific value of the gas of about 54 B.Th.U. per cu.ft.—which must be restored to the extent that the scrubbed gas shall have a calorific value of 535.

Now, assume further that the light oil is to be fractionated so as to produce a first cut containing the fore-runnings and as much of the benzole as possible, a second cut containing a small amount of benzole and as much toluole as possible, a residue left in the still containing a minimum of toluole and most of the material of the original light oil boiling above toluole.

A fair estimate of the volume relation of each of these fractions to the light oil would be :

Benzole and fore-runnings	50%
Toluole fraction	25%
Residue	25%

The benzole fraction may be returned to the gas, and if so returned will restore 0.4 gall. light oil by 50% by 135,000 B.Th.U. = 27 B.Th.U. per cu.ft. to the gas. The toluole fraction will be sent to the refining plant.

The residue should, under present-day conditions, not be returned to the gas, because it will contain a large percentage of gum-formers.

The return of the benzole fraction to the gas will restore 27 of the 54 B.Th.U. per cu.ft. lost by scrubbing, and the scrubbed gas will have a calorific value per cu.ft. of 535. The cost of producing 1,000 cu.ft. of 535 B.Th.U. gas has increased by 2.05c. as shown above, for causes entirely independent of the cost of operating the scrubbing plant, and stripping and fractionating stills.

There may be, of course, an offset to this additional cost, the magnitude of which is very difficult to estimate. That offset may come from the disposition of the benzole and of that fraction of the light oil boiling above toluole. Under favourable market conditions this may be great.

It is not to be taken for granted, however, that because benzole is recovered from the gas, it is going to be immediately saleable. The main outlet for it might be motor benzole, and a smaller, but still a very important, outlet would be to the chemical industry for dyes and synthetic phenol. At this time these markets seem to be quite dull. The marketing of benzole incidental to toluole recovery is too complicated a matter to be discussed in this Paper. I therefore believe that it would be wise to consider that the benzole, produced incidentally to emergency toluole production by gas companies, is going to be returned to the gas partially to make up for B.Th.U. lost by scrubbing out the light oil. In this case, with heavy oil at, say, 3c. per gallon, the benzole will not be worth more than 3c. per gallon.

There will also be an advantage gained by the removal of the high boiling hydrocarbons from the gas, in that they contain a large percentage of gum formers ; their removal should reduce the total cost of servicing customers' appliances through a reduction in the number of pilot outages. The value of this phase of the situation is exceedingly hard to express in cents per 1,000 cu.ft., but it will probably not amount to more than 0.1c. per 1,000 cu.ft.

The residue of the light oil boiling above toluole, containing xylene, resin-formers, styrene and indene, and some naphthalene, has also a commercial value. In most gas-works there is no equipment for fractionating this material or obtaining the more valuable ingredients in any great degree of purity, and therefore it is probable that this residue will have to be disposed of in the crude state, as it is produced.

Suppose that this could be sold at a price which would net 9c. per gallon. In volume it has been assumed as 0.10 gall. per 1,000 cu.ft. (25% of 0.4 gall. light oil).

The credit to the cost of toluole production would be 0.9c. and from above an additional 0.1c. per 1,000 cu.ft. for reduction in customers' service expense, or 1.00c. total. Add to this the credit for benzole and fore-runnings 0.20 gall. per 1,000 cu.ft. at 3c. = 0.60c., making the total credit to the cost of toluole production for products of light oil recovery other than toluole 1.60c.

Applying this credit against the increased operating cost of gas production incidental to toluole recovery, there is still an excess cost of 2.05–1.60 = 0.45c. per 1,000 cu.ft. On the other hand, if there is not an active market for the high boiling residue, it may have to be sold or used at its fuel oil value of not over 2.8c. when heavy fuel oil costs 3c.

The above would indicate that unless conditions are unusually favourable, the credit from the disposal of the benzole and the high boiling residue will not offset the additional cost to a water gas works of changes of operation tending to production of maximum toluole.

There is still another method of disposing of at least a portion of the higher boiling fraction. If conditions warrant, a naphtha fraction may be taken from it and re-cracked by running it on the carburettor of a water gas set. By this means, it may yield as much as 20% of itself as toluole. Its value for this purpose will depend upon the value of the toluole recovered and sold.

No attempt will be made in this Paper to show what sale price for toluole is necessary to make toluole recovery profitable. Its main purpose is to point out that in a normal gas-works, if light oil recovery is to be practised with toluole production as the main objective, certain problems of operation will be encountered, which are :

(1) Preservation of the required calorific value of the gas after scrubbing.

(2) Securing additional material, carburetting oil or something else to restore the loss in calorific value.

(3) Changes in operating method.

(4) Disposition of the products of light oil recovery other than toluole.

These can all be solved, but the solution involves additional cost.

Therefore, my opinion is that in few instances, and only under especially favourable conditions, should gas companies go into toluole recovery.

On the other hand, the gas companies have the ability to produce toluole, and if such toluole is needed by our Government as part of its National Defence Plan, it is the duty of the managements of those companies to recover it with as much economy as possible—but that agency of the Government whose business it is to produce toluole for National Defence should pay the additional costs of operation, as well as those of plant construction.

Appendix I

The data given show the rate of recovery of light oil—benzole, toluole, and naphtha fractions—which may be obtained when operating a water gas set under two different sets of operating conditions :

(A) To produce gas of 530–535 B.Th.U. calorific value at lowest cost per 1,000 cu.ft.

(B) Minimum " reforming " to produce maximum toluole.

	Operating Conditions (A)	(B)
Cycle, minutes	4.6	4.6
Generator air per minute, cu.ft.	11,000	10,000
Steam per minute, lb.	245	226
Blow, % of cycle	32.9	28.7
Run, % of cycle	58.5	64.8
Oil on back-run, % of total oil	29	2
Oil in carburettor, % of total oil	58.5	50.7
Oil in generator, % of total oil	41.5	49.3
Make per set per 24 hours cu.ft.	4,552	3,479
Calorific value of gas, B.Th.U.	534	564
Oil used per 1,000 cu.ft., gal.	4.41	4.11
Generator Fuel per 1,000 cu.ft., lb.	13.26	19.79

Light Oil Scrubbing

This was done on a continuous sample of gas passed through a train of containers partially filled with straw oil. Complete scrubbing of the gas sample was accomplished. The gas passed through the scrubbing train was measured by meter.

The average results of large number of tests are :

	Operating Conditions (A) 111 Cu.Ft.			(B) 92 Cu.Ft.		
Gas Passed Through	*Per 1,000 Cu.Ft.*	*Yield from Carb. Oil % Volume*	*% of the Light Oil*	*Per 1,000 Cu.Ft.*	*Yield from Carb. Oil % Volume*	*% of the Light Oil*
Light Oil Recovered (Distillate to 200° C.)	0.3308	7.43	100.0	0.3170	7.79	100.0
Forerunnings	0.0106	0.24	3.2	0.0115	0.28	3.7
2° Benzole	0.1680	3.77	50.9	0.1263	3.10	39.9
2° Toluole	0.0649	1.46	19.6	0.0813	2.00	25.8
Naphtha—*i.e.*, oil whose boiling point is above that of toluole	0.0320	0.72	9.5	0.0387	0.95	12.0
Washing Loss, Straight Run Residue, Distillation Loss	0.0533	1.24	16.8	0.0592	1.46	18.6

The water gas set from whose operation these results were produced is an 11 ft. 3-shell set equipped with waste heat boiler and back run, having its own individual condenser, relief holder, and meter, and its own oil meter and oil supply tank.

The oil used to carburet is heavy oil of the fuel oil type of the following general description :

Specific gravity, °A.P.I.	12 to 17.
Flash, closed cup	150°F. min.
Viscosity, Saybolt Furol, 122°F., sec.	1550 max.
Conradson carbon	13% max.
Ash	2.5% max.
Enriching value determined by laboratory	100,000 to 110,000 B.Th.U. per gall.
The generator fuel—Gas Retort Coke (hot) and By-Product Coke having an ash content	7% to 9%

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THE HYDRAULIC SEAL IN GASHOLDER CUPS

A Paper to The Institution of Gas Engineers

[Communication No. 236]

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I SUMMARY

This Paper describes the operation of the hydraulic seal in gasholder cups. A brief historical account, dealing principally with the theoretical treatment of the subject by various authors since the year 1889, is given as an introduction to the more advanced form of analysis which is developed from mathematical considerations. The condition known as "blowing" of the cups or the loss of gas from the cups which sometimes occurs when a holder is in commission, is dealt with in detail.

The reasons for the failure of the hydraulic seals in the cups of fully-inflated lifts, as well as for lifts approaching the uncupping position, are discussed and a description is given of the "blowing" of a cup after a hanging lift has grounded. Under normal working conditions the lifts and tank of a gas holder may be out of level to some extent, and the effect of this on the cup seals during the cupping and uncupping operation is emphasized. Various methods of improving the working of existing cups and dips are suggested and the investigation is extended to the design of the cup seals of new gasholders.

In some gasholders, cups and dips are subjected to certain restrictions in operation so that oil films may be maintained on the exposed surface of the water in the cups or on the water inside the holder; these conditions are examined and the resulting procedure to be adopted in the design of cups and dips is explained.

The Paper concludes with a description of an apparatus developed by the Author which may be used for investigating the operation of the cups and dips of existing gasholders.

II INTRODUCTION

The cup and dip rings are provided for the purpose of accommodating a quantity of water at the termination of each lift, so as to form a gas-tight seal between the telescoping sections of the holder when they are inflated. According to A. M'I. Cleland[1], the cup and dip as used to form a hydraulic seal between the lifts of a gasholder was introduced prior to the year 1833, but it is noteworthy that in that year Stephen Hutchison[2] took out a patent which describes a hydraulic seal practically identical with the cup and dip as now in use. In many of the earlier multi-lift holders, the sections of the cup and dip were formed from wrought iron plates and angles, as shown in Figure 1(a). At a later stage, pressed mild steel plates were used, while the construction most favoured was similar to that shown in Figure 1(b).

With the increasing use of steel sections, it has now become general to form the cup and dip rings of channel sections and plates as shown in Figure 1(c). For many years after the multi-lift gasholder had been in use, it was the general practice to counterbalance the floating portion of the holder, as only a small pressure of gas was required for distribution purposes. The telescopic sections were relatively light and, in consequence, no great amount of load was sustained by the cup of an inflated lift, due to the hanging weight of the lower lifts. Within recent years, it has become the practice to provide for greater pressures in gasholders. In the case of spirally-guided gasholders, the weight of the hanging lifts on the cup and dip rings is in many instances considerable, and special attention must therefore be given to this portion of the structure, not only so far as strength is concerned, but also in regard to the amount of water seal available. Long after multi-lift holders were introduced, very little attention was given to the design of the cup and dip seals and it was usual to proportion the depth of the cup by rough rules based merely on the maximum gas pressure thrown by the holder. In many instances, little margin was left for possible differences in

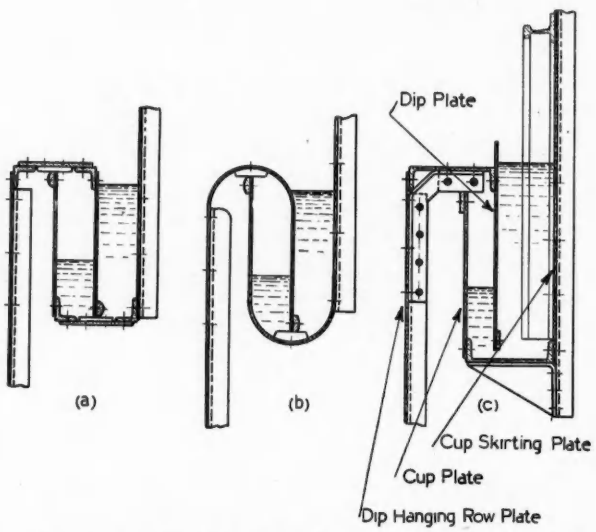

FIGURE 1.—*General Designs of Cup and Dip Sections.*

level of the lifts, evaporation and other conditions, which have since been found of considerable importance in determining the proportions of the cup and dip rings. The fact that when some gasholder lifts uncupped, gas was blown to waste from the cups, was considered a matter of no great consequence, as only a comparatively small amount of gas was lost.

In the year 1889, the question of design of hydraulic cups received more careful study, as is shown by the number of contributions to the technical press at that period[3], but it was not until articles[4] by F. S. Cripps were published in 1910 that the question of blowing of the hydraulic seal on the landing of a lift was systematically investigated. This contribution, however, was restricted to a treatment of the subject in which the three compartments between the plates forming the cup and dip were of equal width.

In the year 1912, J. Schmidt[5] introduced a semi-analytical semi-graphical method of determining the water levels in the compartments of a cup for various critical positions during cupping. A more exhaustive contribution dealing with the *modus operandi* of gasholder cups under normal and

abnormal working conditions was also contributed by A. Mecklenbeck[6]. This latter paper was followed in 1932 by a further treatise by the same author on the subject of cup design[7]. The application of Cripps's method of graphical analysis in determining the position of the water levels in the cup compartments in cases where the three compartments are not equally divided is somewhat tedious, but this difficulty may be overcome to some extent by the use of proportional compasses, which involves a "trial and error" method of analysis[8]. If the cup channel is of a different width from the dip channel, then all three compartments in the cup and dip may be unequal. In this case, it appears desirable to establish the movements of the water levels on a proper mathematical basis. The method described may not only be used in instances where all three compartments of the cup and dip are of unequal width, but it is also applicable to cases where any two compartments, or all three compartments, are of equal width.

The evolutions through which the hydraulic seal in any cup may pass during the inflation and deflation of a gasholder are not easily defined unless the problem is subjected to systematic analysis. It is the object of this Paper, therefore, to present a general method of treatment which may be applied when investigating the behaviour of hydraulic seals in the cups of any holder working under normal or abnormal conditions.

This investigation is principally directed towards the design or analysis of cups and dips constructed of angles or channels as shown in Figures 1(a) and 1(c). The purely mathematical treatment of bent plate cups and dips, as shown in Figure 1(b), is extremely tedious, and as this form of seal is not likely to be considered when designing modern gasholders, only the practical analysis of bent plate cups and dips of existing holders will be described at the conclusion of this Paper.

There is sometimes confusion as to which portions of the cup and dip are represented by the terms "cup plate", "cup skirting plate", "dip plate" and "dip hanging row". In Figure 1(c) these portions of the cup and dip are indicated as understood with reference to this Paper.

III BLOWING OF CUPS OF INFLATED LIFTS

By the term "blowing of the cup" is generally understood the action of the gas in bubbling through the water in the exposed portion of the cup. This occurs when the water level in the cup on the inside of the dip plate is depressed to such an extent that it is slightly below the bottom edge of this plate, thus allowing gas from the holder to escape into the atmosphere. When the lifts of a gasholder are inflated, the hydraulic seal in the cups should be at least 6 in. in depth under the most unfavourable conditions likely to be experienced. It will be realized that in this case the seal in the cups will reach the minimum value when all lifts are fully inflated, as the holder will then be throwing the maximum gas pressure.

The "blowing" of the cup seals of the inflated lifts may be due to one or more of the following causes:

(i) High winds blowing water from the cups.
(ii) Increase in gas pressure due to snow load, additional weighting of bell, or faulty guiding.
(iii) Evaporation of water in cups.
(iv) Lifts working out of level.
(v) Leakage of water from cups.
(vi) Defective anti-freezing apparatus.
(vii) Defective design of cup and dip rings.
(viii) Removal of ice from cups.

When designing new cup and dip rings or investigating the proportions of existing cup seals, allowances require to be made for a number of the above items and these will now be considered in detail.

(i) *Wind Pressure*

From experiments on models it has been found that the distribution of wind pressure on the windward side of an inflated holder is bounded by an angle of approximately 70° at the centre of the structure, while a suction operates over the remainder of the curved surface of the side sheeting. The result of this action of the wind is to depress the level of the water in the exposed portion of the cups coming within the pressure area, and to elevate the water level in the portion of the cups coming within the suction area. As the suction of the wind is greatest at points on the holder at approximately right angles to the direction of the wind, it follows that the water in the cups is more likely to overflow the dips at these places during high winds. The wavelet effect on the surface of the water in the cups due to the lashing action of the wind also tends to contribute towards loss of water from the cup seals.

Unless adequate provision has been made for the action of the wind when determining the proportions of the hydraulic cups, the seals may be seriously reduced, and "blowing" is then liable to occur. There are a number of cases on record where the failure of the cup seals due to wind has resulted in the loss of gas from one or more lifts of a fully inflated holder. From observations made on cups during high winds, it would appear that an allowance of 2½ to 3 in. from the point of dip overflow to the level of the water in the cups is sufficient to ensure satisfactory working of the holder under the most unfavourable conditions likely to be experienced at stations in this country.

In some designs of dips, holes are drilled, or offtake pipes are fitted to the extended portion of the dip plates above the dip channels. Either of these devices enables the surplus water from the cups (due to rain, melting snow, or condensate from the anti-freezing apparatus) to drain away at convenient points round the dips of each lift, while the extended plating above the dip channels forms an effective wind shield for the water in the exposed portion of the cups. In such cases an allowance of only 2 in. may be made from the point of the dip overflow to the highest level of the water in the cup when the holder is fully inflated. The dip plate, however, should in this case be extended a further 2½ in. above the level of the dip overflow, to prevent water being lashed from the cup during high winds.

(ii) *Increase in Gas Pressure*

If a snow load of 5 lb. per sq. ft. is assumed over the entire area of crown sheeting, the gas pressure thrown by the floating holder will be increased by about 1 in. w.g., but this is seldom taken into account when considering the hydraulic seal in gasholder cups, as it is unlikely that the maximum snow load will occur at the same time as a very high wind velocity.

In some cases weights are added to the crown of existing holders for the purpose of increasing the gas pressure. Weighting of gasholders in this or any other way reduces the hydraulic seal in the cups of the inflated lifts by an amount dependent upon the ratio between the widths of the compartments formed by the cup and dip plates and the cup skirting plates. If water in the exposed portion of a cup is already at or above the level at which wind is liable to blow water from the cup, then the hydraulic seal will not only be reduced by an amount depending upon the increased gas pressure, but may also be liable to still further reduction on account of the action of the wind.

Faulty guiding mechanism, causing heavy binding between the guide rails and rollers during inflation of the lifts, also tends to reduce the water seals in gasholder cups, but appreciable increases in gas pressure due to binding are rare, and blowing of the cups because of this feature alone is seldom found.

(iii) *Evaporation*

When the atmosphere is dry, water is lost from the cup due to the process of evaporation. If the water levels are inspected once a week, an allowance of 1 in. off the water level in the cup is generally considered sufficient to provide for the possible loss due to evaporation. As it is reasonable to suppose that loss of water due to evaporation might take place concurrently with the loss of water due to the action of the wind on the cups, the allowance for evaporation should be added to the allowance for wind.

(iv) *Lifts Out of Level*

When a holder is inflated, the lifts may be found to be slightly out of level owing to the fact that the prevailing wind tilts the floating portion of the structure until the clearances between the rails and rollers of the guiding mechanism have been taken up and resistance offered to the overturning moment. The difference in level may be accentuated in some instances by excessive clearances between the guide rails and rollers, inaccuracies in workmanship, or by the tank having subsided. When a holder is first erected, the tank and lifts are seldom more than ½ in. out of level, but in many of the older structures 2 in. out of level is not uncommon. In some instances lifts of comparatively small holders still in commission have been found to exceed 5 in. out of level. When an inflated gasholder is out of level it follows that the hydraulic seal is reduced in the cups of the inflated lifts, because of the

tilting action. The condition is more easily followed on reference to Figures 2(a) and 2(b), which show diagrammatically the hydraulic seal in the cups when the inflated

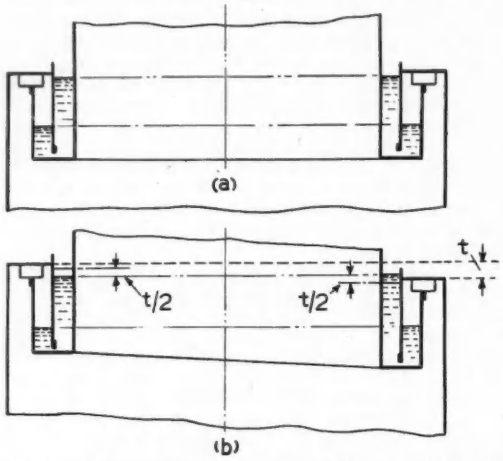

FIGURE 2.—*Diagrams Illustrating the Effect on the Hydraulic Seal in the Cups and Dips of Holders which are Out of Level.*

lifts are level, and also when the lifts are considerably out of level. On comparing these diagrams it will be seen that the cup seal is reduced on the high side of the lifts, but on the low side of the lifts the cup seal is increased. There is therefore a greater tendency for the cups of the inflated lifts to "blow" on the high side of the holder, while on the low side of the holder the tendency is for the cups to lose water over the dips of the hanging lifts or over the lip of the cup plating. Now if t represents the total amount out of level of any lift, then the cup seal on the high side of the holder will be reduced by an amount equal to $t/2$. The effective depth of the cup and dip may also be considered to be reduced by an amount equal to t, to compensate for the fall of the dip on the low side of the holder. No general allowance off the water levels in the cups, such as was made for wind action or evaporation, is therefore possible in this instance, and it is necessary, when investigating the water levels in the cup, to ensure that the effective section of the cup and dip is drawn in accordance with Figure 3.

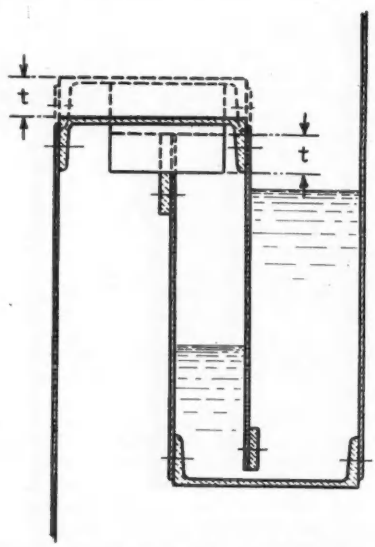

FIGURE 3.—*Diagram Showing Difference between Effective and True or Original Section of Cup and Dip. (The Effective Section of the Cup and Dip is Indicated in Full Lines.)*

The dotted lines indicate the original section of a cup and dip. The full lines represent the effective section of the cup and dip after allowance has been made for the tilting of the lifts just before the uncupping or cupping operation. When designing new holders, the maximum value of t may in general be taken as 2 in., but when considering the cup seals of existing gasholders the maximum value of t may be obtained from actual measurement.

(v) *Leakage of Water*

Leakage of water from the cups of gasholders is sometimes due to the working loose of bolts or rivets attaching the vertical stays or roller carriages to the cup rings. Water may also be lost from the cups through holes in the plating brought about by excessive corrosion. As leakage of water from the cups of inflated lifts obviously reduces the amount of hydraulic seal, "blowing" of the cups may eventually occur and a considerable amount of gas be liberated. Leaky cups constitute a danger and should therefore receive immediate attention.

(vi) *Defective Anti-Freezing Apparatus*

In some of the earlier designs of anti-freezing apparatus no provision was made for the relief of the partial vacuum which was set up in the steam pipes after the apparatus had been shut off; consequently, water was sucked from the cups into the steam pipes and in some instances the cup seals were reduced to such an extent by siphoning that "blowing" took place. In modern anti-freezing apparatus, non-return valves and other safety devices are generally fitted near the circulators in the cups of the various lifts. The possibility of losing water from the cups due to defects in modern anti-freezing apparatus is therefore remote.

(vii) *Defective Design of Cup and Dip Rings*

The design of a cup and dip ring may be considered defective if there is little or no margin of hydraulic seal in the

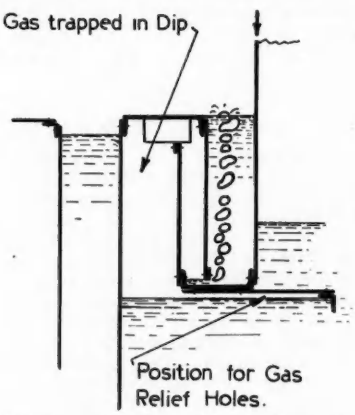

FIGURE 4.—*Diagram Showing the "Blowing" of a Cup Caused by Trapping of Gas under the Cup Stiffening Plate.*

cup when the holder is subject to the most unfavourable conditions of working likely to be experienced. In first class design the minimum amount of seal in the cups of a fully inflated holder should not be less than 6 in., after making allowances for the action of wind, evaporation, and difference in level. There are instances where gasholders have been in continuous service for a considerable period with cup seals of less than 3 in., and practically no allowance has been made for the action of the wind or evaporation. In some cases, however, where holders are erected in exposed positions, high winds have resulted in the loss of gas from one or more of the lifts due to the inadequacy of the cup seals.

(viii) *Removal of Ice from Cups*

If, as a result of the failure of the anti-freezing apparatus, ice should form in the cups of a gasholder, care must be taken to see that the water levels in the cups are maintained when any appreciable quantity of ice has to be removed.

IV BLOWING OF CUPS WHEN SUBMERGING IN TANK WATER

When a holder is being deflated and the cup of any lift begins to submerge in the tank water, a quantity of gas becomes trapped in the dip. As the cup continues to descend

further into the tank, the pressure of the trapped gas is increased and a point may eventually be reached where the water level between the cup plate and the dip plate is depressed to such an extent that some of the trapped gas is liberated beneath the dip plate. In Figure 4 is indicated the manner in which a cup will " blow " under the conditions just described.

The " blowing " of gasholder cups before the hanging lift has grounded on the rest blocks is generally due to the lifts being considerably out of level. In some holders a horizontal plate and angle are used to stiffen the cup as shown in Figure 4. Where this or similar forms of construction are adopted, holes should be drilled or cut in the horizontal plate at frequent intervals round the lift in the position indicated in Figure 4, to prevent gas being trapped in the dip before the underside of the descending cup touches the water in the tank. Where no holes are provided in the horizontal plate, " blowing " of the cups is therefore more liable to occur. If the distance between the cup plate and dip plate is small in comparison to the width of the adjacent compartments of the cup and dip, there is also a greater tendency for the cups to " blow " as they submerge in the tank water. In the case of existing gasholders, " blowing " of the cups in the manner described may sometimes be prevented by attaching extension pieces to the dip channels or plates. In Figure 5(a), (b), (c) and (d)

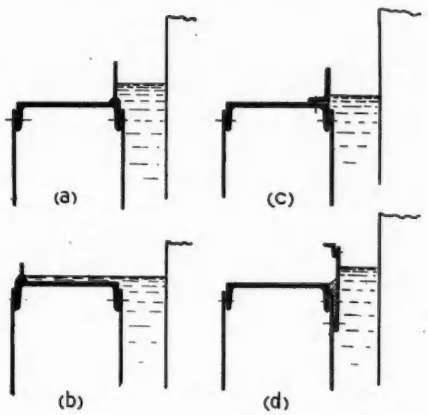

FIGURE 5.—*Various Methods of Increasing the Hydraulic Seal in Existing Gasholder Cups.*

are shown a number of ways in which the extension pieces may be secured to the dips of an existing holder. These extension rings comprise (a) and (b) vertical plates welded to the dip channels, (c) unequal angle section rings secured to the dip channels with set screws, and (d) a built-up section consisting of plates, flats and angles attached to the dip plating by bolts. The extension rings should be continuous round the dips of the lifts, and care must be taken to ensure that the extension pieces do not interfere with the carriages on the lift, or the carriages on the adjacent lifts.

" Blowing " of existing cups may sometimes be prevented by slightly lowering the water overflow level in the tank. The latter remedy should not be adopted unless the operation of the cup has been thoroughly investigated to ensure that sufficient water will be carried up in the cup to maintain an adequate seal as the holder is inflated. The addition of extension pieces to the dip will be effective only in cases where water was found previously to overflow the dips when the lifts were cupped or uncupped, or where an appreciable quantity of water was lost from the cups of inflated lifts by the action of the wind. These propositions will, however, be dealt with in detail later when considering the various positions of the water levels during the cupping and uncupping operations.

V BLOWING OF CUPS AFTER GROUNDING OF LIFTS

Although the conditions are now well known which cause blowing of the gas under the dip plates when the holder is actually uncupping, it will render the following investigation more comprehensive if these conditions are also briefly described.

It has already been shown that when a cup descends into the tank water as a lift is deflated, a point is reached where the gas is trapped in the dip. On grounding of the hanging lift the cup of the floating lift disengages with the dip and continues to descend into the tank. Even if " blowing " has

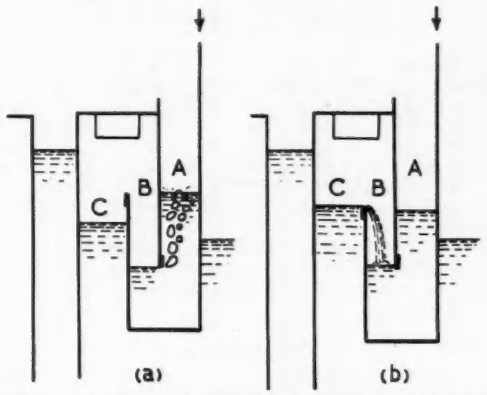

FIGURE 6.—*Diagrams Showing* (a) *" Blowing " of a Cup of a Descending Lift after the Uncupping Operation has taken place;* (b) *Subsequent Flooding of the Cup.*

not previously occurred, the action of a descending lift may carry the water in the cup down so far that the dip plate of the stationary lift can no longer maintain the seal. At this point, the water level in the cup compartment B is just below the edge of the dip plate, as shown in Figure 6(a) and " blowing " of the trapped gas will then take place.

The " blowing " will continue until the lip of the cup plate is just below the water level in compartment C, at which point water will commence to flood the cup and thus increase the seal, as shown in Figure 6(b). If a number of holes are drilled or cut in the cup plate so that the water in compartment C will flood the cup before this critical stage is reached, the seal between compartments A and B will be replenished with water at an earlier stage as the cup descends, and no blowing of gas to waste will then occur.

Flooding holes are generally incorporated in the design of new holders, and these holes are cut or drilled in the cup plates before the erection of the structure. If flooding holes are found necessary to prevent " blowing " of the cups in existing holders, the cup plates may be drilled while the

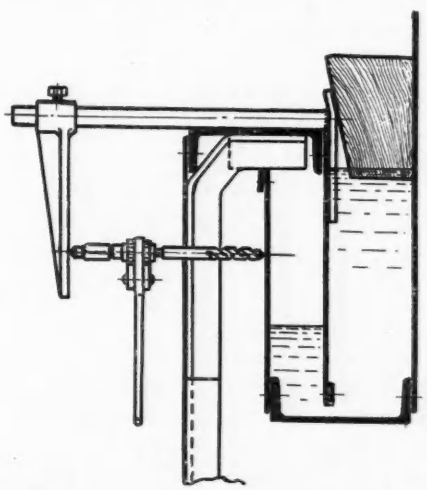

FIGURE 7.—*Method of Drilling Flooding Holes in the Cup Plating of Holders while in Commission.*

holder is in commission. In carrying out this work it is first necessary to drill the hanging row plates, after which the cup plates are drilled in the manner indicated in Figure 7 A clamp is fixed in position over the dip and a ratchet brace is used to rotate the drill.

(To be continued in a forthcoming issue)

ECONOMIES IN GAS DISTRIBUTION OBTAINABLE IN WORKS PRACTICE *

By A. C. BUREAU, B.Sc. *(of Messrs. W. C. Holmes & Co., Ltd.)*

THE exigencies of the times have brought the subjects of benzole recovery and liquor concentration into prominence and, no doubt, many undertakings will benefit from the instillation of such plants, but in numerous cases expansion in this direction has been undertaken principally with the object of assisting in the national endeavour rather than in the normal course of development to ensure cheaper gas by profits obtained within the works or to provide better service to consumers.

The improvement of gas distribution which is possible by treatment of the gas stream within the works, with particular reference to the saving of distribution costs involved, is the subject of this Paper.

Visible Profit

The process of dehydration of gas was first introduced in 1925, and has been widely adopted both in this country and abroad. Although there are some cases where the number of complaints on the district are not very numerous, and the advantages of dehydration may not, therefore, be obvious at first sight, there are still many undertakings which have not adopted the process even where the service to consumers cannot be considered satisfactory.

It is sometimes difficult for an engineer to persuade his Committee or Board of Directors to sanction expenditure on a plant of this kind since no readily visible profit is given in return for the capital expended.

A casual consideration of the question alone shows a lack of foresight in such a view, and a more detailed investigation reveals the fact that quite apart from the undoubted value to the undertaking of maintaining an uninterrupted service, actual monetary savings on the annual distribution bill are achieved of a larger yearly amount than the running costs of the plant, and thus a real profit is shown.

Systems have been introduced using glycerine, calcium chloride solution, and refrigeration, and each of these methods has been described in technical literature, but of these by far the largest number of installations which are in operation in this country utilize the calcium chloride solution method which, to my mind, has the virtues of simplicity in operation and design, economy in working costs, and low capital outlay.

Dehydration has no effect on the operation of the carbonizing system, draws no enviable distinction between horizontal and vertical retort systems, and is readily adaptable to the needs of the smallest and the largest undertakings.

The design and operation of the " Drigas " process has been fully described elsewhere, and this aspect of the subject will not, therefore, be dealt with here except to state that the attention required by the plant is very little, and although for purposes of assessment labour can be charged against the plant, the actual extra expenditure is negligible, since it is usually found that the duty of attention to the installation can be added to the duties of a member of the operating staff of the works without increase of hours. Alternatively, if it is considered advisable to increase the wage of such an operative, then this increase could be regarded as the actual labour cost of the plant. For the purpose of assessing labour costs in this Paper, a figure of two hours per diem at 1s. 3d. per hour has been assumed, although this cost is really in excess of the actual labour cost to the undertaking. In addition to labour, the other costs of dehydration are for steam, water, calcium chloride, oil, grease, &c., for pump lubrication, and interest and depreciation on the capital outlay, in which figure the very small item for plant maintenance can be considered to be included.

The steam is utilized as economically as is practicable, as the exhaust from the steam pump which circulates the solution around the plant is passed through the evaporator for maintaining the required concentration of solution.

The make-up of calcium chloride depends on the leakage from the circuit and the chemical reaction with ammonia if present in the gas. Steps should be taken to prevent physical loss from the system such as screening the evaporator from the wind, taking care not to stop air circulation over it, and preventing leaking from any joints or glands in the system. In the smaller works particular care should be paid to ensure that any leakage from the circulating pump glands should be returned to the system, after separation from lubricating oil, as the loss of this point can be a large proportion of the make-up required.

It has been calculated that the loss from a reciprocating pump working at 20 double strokes per minute, assuming one drop leakage at each double stroke, would, in the course of a year, necessitate the replacement of 11 cwt. of solid commercial calcium chloride.

In the case of a small works with an average daily throughput of 150,000 cu.ft., the total make-up of chloride required was approximately 12 cwt. yearly, and for a larger works averaging 1,800,000 cu.ft. per diem, the make-up was 20 cwt. per annum.

Thus it can be seen that a little care in respect to minor detail can make an appreciable saving on this item, although the chloride make-up does not represent a large proportion of the plant operation charges.

The ammonia content of the gas, since the plant is situated after the purifiers, should not be appreciable under ideal conditions, but unfortunately the washing capacity of every works is not always up to standard and occasionally varying quantities of ammonia pass the purifiers. This reacts with calcium chloride in the presence of carbon dioxide in the following way:

$$2\ NH_4OH + CaCl_2 \longrightarrow Ca(OH)_2 + 2\ NH_4Cl$$

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O.$$

The calcium carbonate is precipitated, forming a sludge which settles out of the system and can be readily identified by chemical test. The degree of loss due to ammonia is shown by the fact that for gas containing 1 grain of ammonia per 100 cu.ft., a replacement of 5·77 lb. of solid commercial calcium chloride is required for every million cu.ft of gas washed.

Fortunately the presence of ammonia in any appreciable quantity at the outlet of the purifiers is only found very occasionally, and attention to the washing system in such a case is necessitated principally to ensure efficient working of the purifiers rather than to make conditions more favourable for dehydration.

To take a representative case of an installation with a maximum daily make of 1,000,000 cu.ft., the cost of dehydration can be computed on the following basis:

	£	s.	d.
Interest and depreciation at 10% on capital	165	0	0
Steam for pumping at 1s. 6d. per 1,000 lb.	18	0	0
Water for cooling at 6d. per 1,000 gall.	45	0	0
Make-up of $CaCl_2$ at £8 per ton	5	12	0
Oil and grease for pumps, &c.	2	0	0
Labour allocation, 2 hr./diem at 1s. 3d. per hr.	45	12	0
Total annual cost	£281	4	0

Assuming an annual make of 200 million cu.ft., this means that the dehydration cost would be 0·335d. per 1,000 cu.ft. With a declared calorific value of 450 B.Th.U. per cu.ft. this would be 0·074d. per therm.

In this particular case a plant situated at the outlet of the holder has been assumed for reasons stated later, which would have a capacity corresponding to the maximum hourly demand on the district. In the majority of cases this maximum hourly send-out is about 2 to 2½ times the hourly make, and so in the case cited above the plant would have an actual capacity of 2,500,000 cu.ft.

The cost of dehydration is slightly reduced if the plant is placed in the gas stream between the purifiers and the holder as the following detailed costs show, taken in the same case of an undertaking of 1,000,000 cu.ft. maximum daily make:

	£	s.	d.
Interest and depreciation at 10% on capital	125	0	0
Steam for pumping at 1s. 6d. per 1,000 lb.	12	0	0
Water for cooling at 6d. per 1,000 gall.	30	0	0
Make-up of $CaCl_2$ at £8 per ton	5	12	0
Oil and grease for pumps, &c.	2	0	0
Labour allocation, 2 hr./diem at 1s. 3d. per hr.	45	12	0
Total annual cost	£220	4	0

Hence, with an annual make of 200 million cu.ft., the cost of dehydration with the plant at the inlet of the holder would be 0·264d. per 1,000 cu.ft. as against 0·335d. per 1,000 cu.ft. with a plant at the outlet of the holder.

* From a Paper to the Scottish Junior Gas Association (Eastern District).

Although dehydration is cheaper with the plant placed at the inlet of the holder, it has been found in practice that the conditions under which carbonization takes place in certain undertakings are favourable to the production of vapour phase gum. This particular type of gum is persistent and requires time to allow for deposition, and apparently the presence of water vapour assists in this. Thus, if the " Drigas " plant is placed after the holder it has been found that this type of gum is precipitated in the holder, but if on the other hand the gas in the holder is dry, then the gum requires more time for deposition, and comes down at more inconvenient points on the district.

This is not necessarily the case with all undertakings, and a large number are successfully operating dehydration plants at the inlet of the holder without gum trouble on the district. However, since it is at present difficult to be certain whether such a trouble might arise with an undertaking installing the process, it is often considered advisable to install the plant at the outlet of the holder.

The reduction of gas volume brought about by dehydration and which was for a few years after the introduction of the process definitely chargeable against the plant has now been officially recognized, and due allowance is made in the computation of the calorific value. The loss of volume by the removal of water vapour is of the order of 1% on the saturated volume, and hence the actual calorific value is raised by between 4 and 5 B.Th.U. per cu.ft.

In the case of dehydrated gas the dewpoint is determined and the equivalent volume correction applied to the result of the Boys calorimeter test as prescribed by the Gas Referees, and therefore this point does not now figure in the debit side of the process.

The advantages conferred by dehydration are many, and though difficult to express in terms of money they are none the less real. The distribution system offers a vast surface of iron or steel to the gas stream, and the resultant condensate, which can be slightly acid or saline, offers favourable conditions for internal corrosion of mains and services. Such corrosion not only reduces the life of pipes, but also reduces the carrying capacity of the system and causes rust stoppages. In addition, the deposition of water can itself block a service line or produce a badly oscillating gas flow if a pocket of water is formed in a sunken main.

The removal of water vapour to the point at which it cannot be deposited has, therefore, the effect of rendering the distribution system practically permanent and ensuring a constant supply of gas to the consumer. Other advantages are that steel mains may be employed to a greater extent, thus reducing the cost of laying new mains, syphon pumping is eliminated and district meters have a longer life.

The reduction of consumers' complaints, besides involving a considerable saving in servicing costs, must also be a very valuable contribution to the maintenance and expansion of gas sales, since a constant trouble-free service must be the basis of the Gas Industry's reply to electrical competition. If the gas supply is faulty and unreliable, it is useless to canvass for bigger sales or even to maintain the present market against competitors who have other advantages to offer.

Thus the principal advantages of dehydration lie rather in the direction of general policy than of monetary returns.

Nevertheless, the general savings to be obtained are considerable, though difficult to assess from the overall costs of the system, since the items of expenditure classed under the general heading of gas distribution which are affected vary from year to year.

Repairs to Mains

For instance, the cost of replacement and repair of mains is not, in ordinary circumstances, a yearly constant, as renewals and the laying of new services are carried out as and when opportunity and necessity dictate.

The following two cases have been given by two undertakings and the proporation of dehydration cost saved on this heading is shown :

Annual throughput of works	370 million cu.ft.	680 million cu.ft.
Annual saving on main and service costs	£2,226	£2,713
Reduction in cost in pence per 1,000 cu.ft.	1.444d.	0.957d.
Cost of dehydration	0.270d.	0.205d.
Reduction in cost expressed as a percentage of dehydration costs	535%	467%

The savings thus shown are of such an order that they call for some comment, but whilst it is realized that these figures cannot be regarded as strictly comparable, at the same time they confirm the theoretical consideration of the advantage of dehydrated gas in the distribution system.

Meter Repairs

Figures are available also in connexion with the saving on meter repairs and are set out below in the same manner.

Annual throughput of works	370 million cu.ft.	560 million cu.ft.	1,600 million cu.ft.
Annual saving on meter repairs	£1,053	£1,602	£1,640
Reduction in cost in pence per 1,000 cu.ft.	0.683d.	0.686d.	0.246d.
Cost of dehydration	0.270d.	0.225d.	0.155d.
Reduction in cost (percentage of dehydration costs)	253%	305%	159%

Here, again, although the difficulty of computing the saving effected is realized, the figures shown do confirm the kind of economy involved.

Consumers' Complaints due to Water

Figures have been given in the Technical Press with respect to the reduction of complaints due to water in services brought about by dehydration. Assuming an average cost for the attention to each complaint of 2s. 6d. per visit, which is probably not excessive since both wages and travelling expenses must be charged and the furthest points of the distribution system are frequently involved, we can roughly arrive at the savings in cost under this head and the percentage of this on the cost of dehydration as follows :

Annual throughput of works	370 million cu.ft.	560 million cu.ft.	1,120 million cu.ft.
Annual reduction of complaints attended to	888	3,800	4,252
Reduction in costs of servicing at 2s. 6d. per visit	£111	£450	£531
Reduction in cost in pence per 1,000 cu.ft.	0.079d.	0.193d.	0.114d.
Cost of dehydration	0.270d.	0.230d.	0.175d.
Reduction in cost expressed as a percentage of dehydration costs	29.2%	83.9%	65.1%

Syphon Pumping

The reduction in syphon pumping cannot usually, in the smaller works, represent a direct saving, as the attention to syphons formed part of the duties of an employee who would still be retained after the introduction of the dehydration plant. He would actually still inspect the syphons very occasionally, but the saving of time in this respect would enable him to spend more time on other duties.

In the case of an installation with an annual make of 1,120 million cu.ft., the annual saving in wages alone was around £2 per week or £100 per annum. This saving works out at 0.022d. per 1,000 cu.ft. as compared with a dehydration cost of 0.175d. per 1,000 cu.ft., or 12½% of dehydration costs.

Hence we see that with works producing between 370 million and 1,600 million cu.ft. per annum, the saving on repairs to mains is between 400% and 500%, on meter repairs 150% to 300%, on servicing complaints 30% to 80%, and on syphon pumping about 10% of the dehydration cost. This indicates that the total savings effected lie between 590% and 890% of the dehydration cost.

Thus the effective profit is of the order of 5 to 9 times the cost of dehydration, or in the region of 1d. to 2d. per 1,000 cu.ft.

Naphthalene Removal

Particularly in the case of undertakings carbonizing in horizontal retorts the trouble on the district which can be caused by naphthalene is well known, and the installation of rotary washers, in which one section dealt with naphthalene and the other with water vapour, was a very extensive practice some years ago. It was principally with the object of reducing the cost of oil that the continuous automatic type of wash oil regeneration plant was introduced in 1931, and from this has developed the modern design of continuous benzole recovery plant, which combines the recovery of benzole with the removal of naphthalene. It is not proposed to deal at any length with the subject of naphthelene removal in this Paper since it is now so inextricably bound to the subject of benzole recovery, which should by now be tolerably well known on account of its perennial appearance in the Technical Press. The advantages in assuring constant service to the consumer and eliminating service charges on this account are perfectly clear, and the direct saving involved is considerable.

The reduction in number of naphthalene complaints varies owing to the differing quantities of naphthalene present in the gas, although this reduction appears to be somewhat greater than the similar figure for complaints due to water.

In the case of the undertaking producing 370 million cu.ft. which was cited above in respect to dehydration, the reduction of complaints due to naphthalene was 1,671, which at a cost of 2s. 6d. per visit gives an annual saving of £209, or 0.136d. per 1,000 cu.ft.

Removal of Organic Sulphur Compounds

This subject has been brought into prominence of recent years and processes involving absorption by oil washing have been devised under the joint patents of the Gas Light & Coke Company and Messrs. W. C. Holmes & Co., Ltd., of Huddersfield, and a number of installations have now been put into operation or are being erected. The principles involved have been described elsewhere and it is sufficient here to state that the operation is simple. The design generally is similar in kind to a benzole recovery plant of modern type, but the quantity of oil circulated is about three to four times as much as in a benzole plant designed to extract 85% of the available benzole in the gas. The cost of a desulphurization plant, therefore, is somewhat higher than a benzole plant recovering the same quantity of benzole. The principal difference is in the capital cost, and in the steam and water consumptions owing to the circulation of more oil.

The overall cost of desulphurization is largely dependent on the economics of benzole recovery, although the plant is designed to allow for the recovery of varying amounts of benzole and it is not necessary to recover the full amount of benzole of which the plant is capable. Therefore, if a desulphurizing plant is introduced and a profit is obtained from the sale of the benzole produced, the advantages of sulphur removal thus obtained are enjoyed in addition to a return on capital in the works itself. In such circumstances, however, it could be argued that a good case is offered for the installation of a benzole plant, and that the same recovery of benzole could thus have been obtained with less expenditure. Perhaps, therefore, the fairest way to express the cost of desulphurization is to prepare balance sheets showing the economics of benzole recovery with—

(*a*) the installation of a benzole plant designed to recover 85% of the benzole available in the gas ; and

(*b*) the installation of a desulphurizing plant with the same recovery of benzole.

Taking a typical case where the production of benzole might be expected to give a profit, balance sheets are shown in which the installation of a benzole plant and a desulphurizing plant are compared. The figures assumed are generally based on prices and carbonizing conditions which might be found in Scotland, and the yield of 2½ gall. per ton is assumed from the carbonization of Scottish coals. It should be understood that the case taken is hypothetical and cannot be regarded as generally applicable, since the economics of benzole recovery vary very considerably, particularly where vertical retorts are concerned, and each case should be investigated separately.

Financial Statements for Equivalent Benzole Recovery and Desulphurizing Plants

Data *before* introduction of plants :	
Annual make	400 million cu.ft.
Annual coal requirements	22,222 tons
Gas yield	18,000 cu.ft. per ton
Declared calorific value	450 B.Th.U. per cu.ft.
Thermal yield	81.0 therms per ton
Coke yield	9.0 cwts. per ton
Annual coke yield (available for sale)	10,000 tons
Tar yield	16 gall. per ton
Annual tar yield	355,552 gall.
Data *after* introduction of plants :	
Annual make	400 million cu.ft.
Annual coal requirements	25,600 tons
Gas yield	15,533 cu.ft. per ton
Calorific value before washer	473 B.Th.U. per cu.ft.
Thermal yield	69.9 therms per ton
Coke yield	9.52 cwt. per ton
Annual coke yield (available for sale)	12,185 tons
Tar yield	15 gall. per ton
Annual tar yield	384,000 gall.

	Benzole Plant.	*Desulphurizing Plant.*
Extra coal requirements per annum	3,378 tons	3,378 tons
New washing oil per annum	6,400 gall.	6,400 gall.
Steam for plant ,,	2,688,000 lb.	5,120,000 lb.
Water for plant ,,	3,200,000 gall.	8,320,000 gall.
Extra coke produced ,,	2,185 tons	2,185 tons
Surplus steam available per annum	1,000,000 lb.	1,000,000 lb.
Extra tar produced ,,	28,448 gall.	28,448 gall.
Naphtha produced ,,	6,400 gall.	6,400 gall.
Benzole produced ,,	64,000 gall.	64,000 gall.

Annual Cost of Production :	*Benzole Plant.*	*Desulphurizing Plant.*
Extra coal at 26s. per ton	£4,391	£4,391
New washing oil at 10d. per gall.	267	267
Interest and depreciation at 10% on capital	420	1,000
Maintenance at 2½% on capital	105	250
Labour, 1 hr. daily at 1s. 3d. per hr.	23	23
Steam for plant at 1s. 6d. per 1,000 lb.	202	384
Water for plant at 6d. per 1,000 gall.	80	208
Cost of production	£5,488	£6,523
Annual Revenue from Residuals :		
Extra coke at 30s. per ton	£3,278	£3,278
Surplus steam available at 1s. 6d. per 1,000 lb.	75	75
Extra tar at 2d. per gall.	237	237
Naphtha produced at 6d. per gall.	160	160
	£3,750	£3,750
Nett Cost of Production	£1,738	£2,773
Revenue from benzole at 1s. 1½d. per gall.	£3,600	£3,600
Annual profit	£1,862	£ 827

Hence cost of desulphurization is £1,862—£827, or £1,035 per annum.
On an annual make of 400 million cu.ft. at 450 B.Th.U. per cu.ft., this is :

0.621d. per 1,000 cu.ft.
or 0.138d. per therm.

Note.—1s. per ton on the coal price reduces profit by £169 per annum.
1s. per ton on the coke price increases ,, £109 ,,
1d. per gall. on the benzole price ,, ,, £266 ,,

The various methods of presenting balance sheets for benzole recovery have provoked much controversy and widely different opinions are held, but if any items have been omitted here which in the view of some engineers ought to be included, it should be borne in mind that the majority would be identical for both cases and upon subtraction cancel out.

It will be seen that, in this particular case, the difference in profit is £1,035 per annum on an annual output of 400 million cu.ft., which represents a differential cost of 0.621d. per 1,000 cu.ft. or 0.138d. per therm.

In the case of an undertaking at which benzole recovery cannot show a profit, then such a comparison of data sheets is unnecessary since no case can be made for benzole recovery on its own merits, and thus the loss shown on the data sheet for the installation of a desulphurizing plant is the cost of desulphurization.

Owing to the widely varying prices and carbonizing conditions there is some difficulty in expressing the cost of desulphurization for different throughputs on the lines of the curve shown for dehydration, and therefore this has not been attempted, but such a cost as 0.6d. per 1,000 cu.ft. cannot be considered excessive in view of the advantages conferred by the process.

Reduction in service costs for appliances such as water heaters, and any apparatus in which condensation is liable to occur, can be expected, and, above all, the reduction of the sulphur dioxide content of the products of combustion renders them much less objectionable and removes one of the main disadvantages of gas. Sales of gas cannot only be maintained but increased, and new markets opened up. In the domestic field a notable example is the case of flueless heaters and portable gas fires which can be installed without objections to the unpleasantness of the combustion products. In certain specialized cases low sulphur gas can be employed in industrial concerns where the prevention of bloom on glass and pottery is an important point, and no doubt other cases of a similar nature may yet be encountered in the field of industrial supply.

As in the case of dehydration the main advantages of desulphurizing lie in the direction of general policy with regard to the supply of a better product and the reduction of complaints on the district than on the reduction of distribution costs, but there is little doubt that substantial savings on appliance servicing can be made, and it has been claimed that a substantial reduction of gum trouble has been shown.

The majority of desulphurizing plants now in operation are of relatively recent construction, and the actual extent of the expected reduction of costs on appliance servicing cannot be properly determined as yet, although it is being shown qualitatively.

Some information, however, has been given by Mr. Norman Hudson, of Mirfield, in a Paper presented at a meeting of the Manchester District Association on Oct. 20, 1939, in which the claim was made that the maintenance bill on after-sales services was reduced upon the introduction of a desulphurizing plant. Taking the case of a small instantaneous gas water heater he showed that whereas prior to the operation of the plant it was necessary to service twice a year, when the appliance was burning low-sulphur gas servicing every 18 months was perfectly satisfactory.

The average cost in labour, material and transport was computed to be about 3s. per visit, and thus it is seen that for each appliance of this type a saving of after-sales servicing of 6s. in 18 months, or 4s. per annum, may be expected.

The case of a storage water heater in continuous use was also cited, and here it was shown that with low-sulphur gas servicing once in twelve months was considered too frequent against three times per annum previous to desulphurization, thus giving a saving of about 6s. per annum.

Where large numbers of these appliances have been installed the total annual saving involved becomes a considerable item.

It was also shown by Mr. Hudson that the installation of small water heaters, which may often only bring an increased annual consumption of the order of 10,000 cu.ft., may actually result in a loss to the undertaking owing to the service costs involved if the sulphur content of the gas is appreciable. It was estimated that the gross annual profit due to the sale of gas used in such an appliance is of the order of 6s. Thus, two visits per annum would practically eliminate the profit.

The reduction of servicing brought about by the supply of

gas of low-sulphur content, therefore, has the effect of converting the potential loss on the fitting of small appliances into a profit and enabling the sale of such appliances to be extended.

Doubtless similar information will soon be available from other installations and the extent of economy effected will be known over a wider range. In the meantime, the theoretical considerations alone are sufficiently strong for the principle of desulphurization to be widely approved.

Benzole Recovery

One of the incidental advantages attendant upon the introduction of benzole recovery is the partial removal of organic sulphur which is effected. In the case of a benzole plant designed to recover 85% of the available benzole in the gas the reduction of organic sulphur content can be as much as 30% to 40% as against 70% to 80% in the case of a desulphurizing plant. South of the Tweed, where the organic sulphur content of gas can be over 30 grains per 100 cu.ft., it is essential to instal a desulphurizing plant to reduce the sulphur below 10 grains per 100 cu.ft., at which concentration it has been agreed that flueless heating without discomfort becomes possible (see report by the Royal College of Physicians entitled " Domestic Heating by Gas " issued December, 1936), but in Scotland certain undertakings produce gas with an organic sulphur content of 12 to 15 grains per 100 cu.ft., and in such cases the introduction of a suitable benzole plant can reduce the sulphur content to below 10 grains per 100 cu.ft. Even so it is theoretically preferable to reduce the sulphur to as low a figure as possible, but the question of capital outlay does definitely require consideration in these times and may dictate the practical limit.

The reduction of the organic sulphur content of the gas in common with the removal of naphthalene incident to the process is never credited to the plant in a balance sheet, but there is no doubt that the advantages of such sulphur removal should not be overlooked, particularly where the introduction of a benzole plant might be expected to reduce the sulphur content below 10 grains per 100 cu.ft., such as may occur with some Scottish works.

Undertakings which have preliminarily examined the economic prospects of benzole recovery in many cases may have decided to leave the matter in abeyance for the time being, since, although a profit might be shown under war conditions, it may very possibly become a loss after the cessation of hostilities. The main objection raised where this view is taken is that a considerable capital might thus be laid out for a plant which may fail as a revenue producer, perhaps in a short time, and then the capital would be lying idle if the plant were shut down, and many engineers are unable to recommend a venture of this type for patriotic reasons alone if the return on capital is not certain. An excellent suggestion has been made to overcome this difficulty, and plant has been ordered by one Scottish undertaking with the aim of making the fullest use of the capital outlay in any circumstance which may arise after the war.

In this case it is intended that, if at any time benzole recovery should cease to yield a profit, the benzole washer, storage tank, and the rack coolers from the stripping unit, would be re-utilized in a dehydration plant. The cost of conversion to a " Drigas " plant is thus reduced to a minimum, since the washer, the cooler, and evaporator (which last two would be built largely from the rack cooler from the benzole plant) and the tank constitute by far the largest cost of the plant.

If there is any suspicion that gum is present the reconstructed " Drigas " plant could be placed at the outlet of the holder, as the same washer should be large enough to deal with dehydration of the maximum hourly output to the district. This is because the washing surface of a washer designed to extract around 85% of the benzole available in the gas is usually from 2½ to 3 times the washing area of an equivalent dehydration washer, and at the same time the maximum hourly output to the district is 2 to 2½ times the hourly make.

Thus by conversion to dehydration at a later date, if necessary, the majority of the capital expended in assisting the immediate war effort could be turned to good account.

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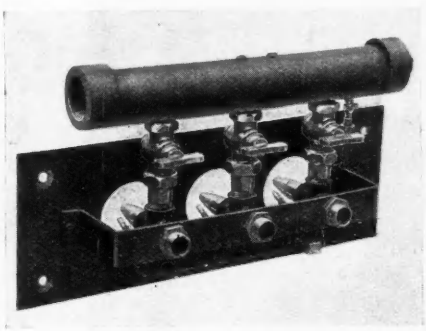

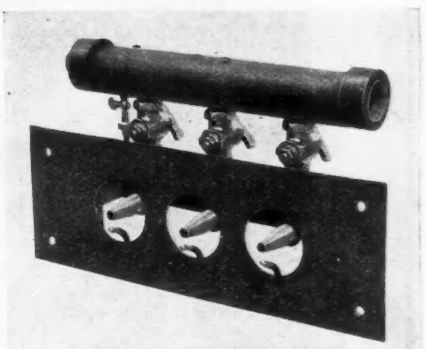

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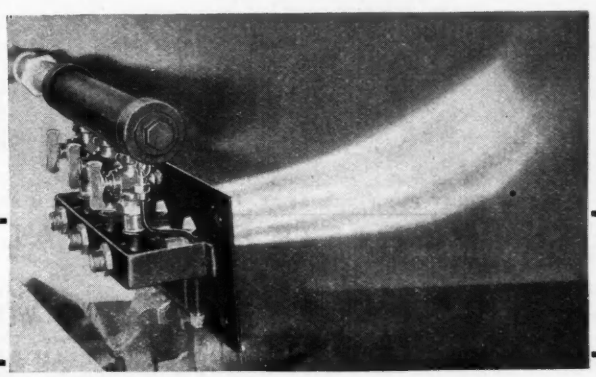

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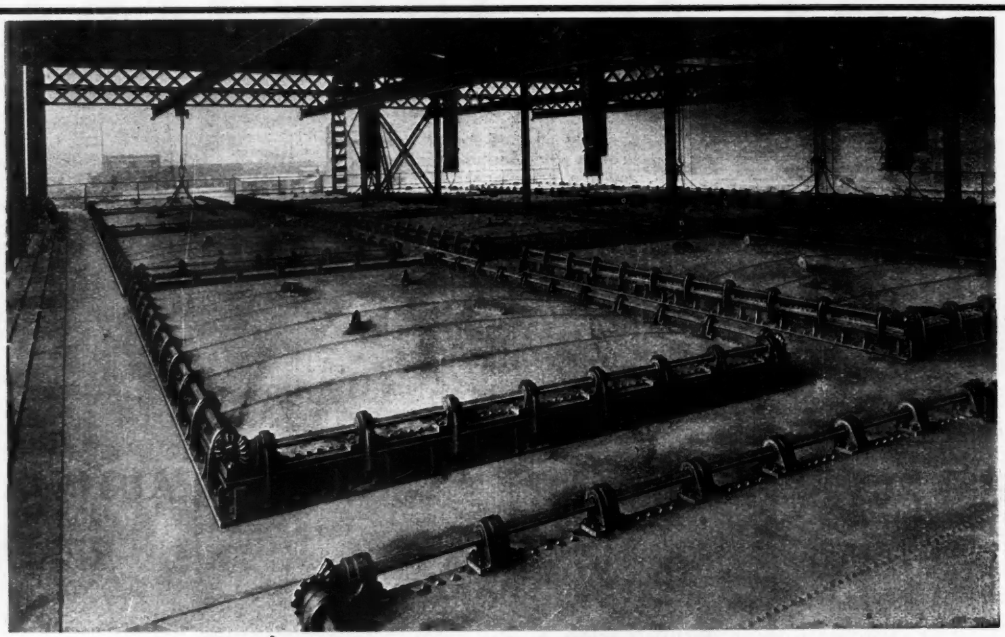

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Gas Products Prices

The London Market

Dec. 30.

Prices of Tar Products in the London Market remain to-day unaltered. Present values are as follows: Pitch is nominal; creosote is about 4⅜d. to 5d. per gallon; refined tar 3⅜d. to 4d.; the price of pure toluene under the Ministry of Supply Toluene No. 2 Order is 2s. 5d. per gallon; pure benzole is 1s. 10d.; 95/160 solvent naphtha is about 2s. 3d.; 90/160 pyridine about 15s.; all per gallon naked; refined naphthalene crystals £23 per ton in bags; all *ex* Makers' Works.

The Provinces

Dec. 30.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 1s. 10d. (controlled by the Control of Toluene No. 2 Order, July 5, which fixes the maximum price at which this material may be sold). Coal tar, crude naphtha, in bulk, North 9½d. to 10d. Solvent naphtha, naked, North, 1s. 9d. to 1s. 10d. Heavy naphtha, North, 1s. 5d. to 1s. 6d. Creosote, *ex* works, in bulk, North liquid and salty, 4¼d. to 4⅜d.; Scotland, 4¼d. to 4⅜d.; low gravity, 4¼d. to 4⅜d. Fuel Grade 4d. to 4¼d. Carbolic acid, 60's, 3s. 9d. to 3s. 10½d. Naphthalene, £15 to £20. Salts, 75s. to 85s., bags included. Anthracene, "A" quality, 4¼d. to 4⅜d. per minimum 40% purely nominal. Heavy oil: Unfiltered anthracene oil (min. gr. 1,080), 5¼d. to 5½d.; filtered heavy oil (min. gr. 1,080), 5⅜d. to 6d.; heavy anthracene oil gr. less than 1,080, 6d. to 6¼d.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note in our issue of Sept. 4, 1940, p. 404.

Tar Products in Scotland

GLASGOW, Dec. 28.

Trading is proceeding normally with prices of most products well maintained.

Refined tar is now no more than holding its own, but price in the home market is controlled at 4½d. to 4⅝d. per gallon. For export supplies are offered at 3½d. to 3⅝d. per gallon, both f.o.r. naked.

Creosote oil remains in good call with the prospect of substantial business being placed by the railway companies for delivery over the coming year. Values are as under: Specification oil, 5d. to 5½d. per gallon; low gravity, 6d. to 6½d. per gallon; neutral oil, 5⅜d. to 6d. per gallon; all *ex* Works in bulk.

Cresylic acid is in small but regular call with prices for reasonable quantities as follows: Pale, 99/100%, 2s. to 2s. 2d. per gallon; Pale, 97/99%, 1s. 9d. to 1s. 10d. per gallon; Dark, 97/99%, 1s. 6d. to 1s. 7d. per gallon; all *ex* Works in buyers' packages.

Crude naphtha continues to be well looked after at 6¾d. to 7½d. per gallon *ex* Works in bulk, according to quality.

Solvent naphtha is quite active at 1s. 8½d. to 1s. 9d. per gallon for 90/160 grade and 1s. 4½d. to 1s. 5½d. per gallon for 90/190 heavy naphtha.

Pyridine is still quoted at 17s. to 18s. per gallon for 90/160 grade, and 19s. to 20s. per gallon for 90/140 grade.

Calendars, Diaries, &c., Received.

We have received from the Parkinson Stove Company, Ltd., a Calendar with the same fine lion's head design as has appeared in their recent advertisements. This, we are told by their Publicity Manager, was designed below ground during the height of one of the recent severe air-raids.

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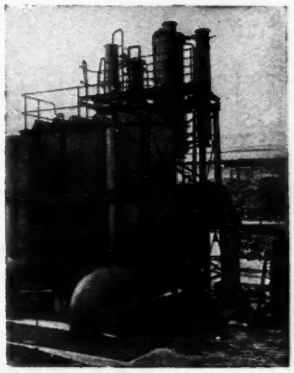
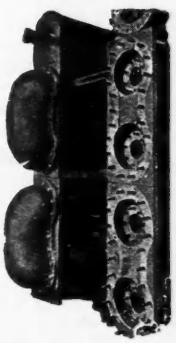


"Permac" Joints in a Gas Works



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GAS STOCKS AND SHARES

The holidays naturally curtailed the value of business on the Stock Exchange last week, but markets were firm and there were few sellers in evidence. British Funds were particularly strong and all finished higher—2½% Consols closing ¼ up at 76½. There were more enquiries for Home Rails, and even the junior stocks found support. A feature of the week, although it appeared after the close of business, was the Chancellor of the Exchequer's statement relative to the Government's two new savings issues—the 3% Savings Bonds, 1955–1965, and the 2½% National War Bonds, 1946–1948, the latter to replace the present issue as at the end of 1940. Both securities to be "on tap."

Very little business was done in the Gas Market, and recorded transactions were almost entirely confined to the stocks of the leading undertakings. In the Official List the only movement of note was a rise of 4 points in the Oriental Stock to 105, and Gas Light preference issues also closed higher. South-Eastern Gas 4% preference reacted 6d. to 13s. 6d. On the Provincial Exchanges Bath Consolidated dropped 1½ points to 96, otherwise the changes were all due to *ex* div. markings. There were no alterations of note in the Supplementary List.

Quotations on the London and Provincial Stock Exchanges

OFFICIAL LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Dec. 26.	Rise or Fall on week.
1,767,439	Sept. 16	7	7	Alliance & Dublin Ord. ...	112—122	...
374,000	July 1	4	4	Do. 4 p.c. Deb. ...	90—95	...
957,608	Nov. 4	5	5	Asscd. Gas & Water U'd'ts Ord.	12/—14/–	...
500,000	,,	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	15/6—17/6	...
535,545	,,	4	4	Do. 4 p.c. Red. Cum. Pref.	14/6—16/6	...
336,646	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	12/—14/–	...
561,370	Aug. 12	7	7	Barnet Ord. 7 p.c.	98—103	...
300,000	Oct. 14	1/9⅗	1/4⅘	Bombay, Ltd.	19/6—21/6	...
690,407	Aug. 19	7	7	Bournemouth 7 p.c. max. ...	100—110	...
362,025	Dec. 16	4	4	Do. 4 p.c. Deb. ...	79—84	...
659,955	Aug. 19	6⅜	4⅜	Brighton, &c., 5 p.c. Con. ...	65—75	...
855,000	Sept 30	8	6	Brit. Gas Light Ord.	75—85	...
545,000	Dec. 16	5½	5½	Do. 5½ p.c. 'B' Cum. Pref	108—113	...
120,000	,,	4	4	Do. 4 p.c. Red. Deb.	73—78	...
10,000	Nov. 6, '33	6	4	Cape Town, Ltd., 4½ p.c. Cu. Pf.	¼—¾	...
626,860	July 15	5⅗	6	Cardiff Con. Ord.	89—94	...
24,500	Sept. 23	7	7	Colombo Ord. 7 p.c. Pref. ...	19/—21/–	...
764,169	Oct. 7	/11.48	-/11.48	Colonial Gas Assn. Ltd. Ord. ...	14/—16/–	...
400,000	,,	1/3.30	1/3.30	Do. 8 p.c. Pref. ...	19/—21/–	...
1,748,935	July 22	2	3	Commercial Ord.	37—42	...
620,000	Dec. 9	3	3	Do. 3 p.c. Deb.	57—62	...
286,344	Aug. 19	5	5	Do. 5 p.c. Deb.	87—92	...
807,560	Aug. 12	7	6	Croydon sliding scale	83—88	...
644,590	,,	5	5	Do. max. div.	79—84	...
620,385	July 1	5	5	Do. 5 p.c. Perp. Deb. ...	90—95	...
179,500	Aug. 19	5⅜	5	East Surrey 'B,' 5 p.c.	60—70	...
176,461	Dec. 16	5	5	Do. 5 p.c. Deb. (Irred.)...	87—92	...
250,000	Nov. 11	4	6	Gas Consolidation Ord. 'B' ...	13/6—14/6	...
250,000	Nov. 11	4	4	Do. 4 p.c. Red. Cum. Pref.	15/—17/–	...
19,123,081	July 29	3⅜	4½	Gas Light & Coke Ord. ...	14/—15/-a	...
2,600,000	,,	3½	3½	Do. 3½ p.c. max.	50—55	...
4,477,106	,,	4	4	Do. 4 p.c. Con. Pref. ...	72—77	+1
2,993,000	July 8	3⅜	3⅜	Do. 3⅜ p.c. Red. Pref. ...	82—87	...
8,602,497	Dec. 2	3	3	Do. 3 p.c. Con. Deb. ...	69—74*	+2
3,642,770	,,	5	5	Do. 5 p.c. Red. Deb. ...	100—105	...
3,500,000	,,	4½	4½	Do. 4½ p.c. Red. Deb. ...	98—103	...
700,000	Sept. 9	3½	3½	Do. 3½ Red. Deb.	80—85	...
3,600,000	May 13	4	8	Imperial Continental Cap. ...	39—44	...
43,820	July 29	3½	3½	Do. 3½ p.c. Red. Deb. ...	63—68	...
231,978	Aug. 19	5	5	M.S. Utility 'C' Cons.	68—73	...
918,657	,,	4	4	4 p.c. Cons. Pref.	72—77	...
675,000	Nov. 11	†4	†4	Montevideo, Ltd.	52—57	...
300,000	Nov. 18	7	9	Oriental, Ltd.	100—110	+5
368,537	Dec. 9	8	6½	Plymouth & Stonehouse 5 p.c.	88—98	...
621,667	Aug. 19	8½	7½	Portsmouth & Gosport Cons.	90—95	...
648,999	Sept. 16	1/1	1/1½	Severn Val. Gas Cor. Ld. Ord.	13/—15/–	...
597,972	,,	-/10⅜	-/10⅝	Do. 4½ p.c. Cum. Pref. ...	15/6—17/6	...
2,528,714	Sept. 2	1/–	-/7½	South East'n Gas Cn. Ld. Ord.	9/—11/–	...
1,000,000	,,	-/10⅜	-/10⅝	Do. 4½ p.c. Red. Cum. Pref.	14/—16/–	...
1,068,869	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	12/6—14/6	—/6
4,709,895	Aug. 5	4	4	South Met. Ord.	53—58	...
1,135,812	,,	6	6	Do. 6 p.c. Irred. Pref. ...	100—105	...
850,000	,,	4	4	Do. 4 p.c. Irred. Pref. ...	69—74	...
1,895,445	July 1	3	3	Do. 3 p.c. Perp. Deb. ...	60—65	...
1,000,000	July 15	5	5	Do. 5 p.c. Red. Deb. ...	97—102	...
1,543,795	July 22	3	4	South Suburban Ord. 5 p.c. ...	62—67	...
512,825	July 8	5	5	Do. 5 p.c. Perp. Pref. ...	85—90	...
500,000	,,	4	4	Do. 4 p.c. Perp. Pref. ...	63—68	...
250,000	,,	3⅜	3⅜	Do. 3⅜ p.c. Red. Pref. ...	80—85	...
888,587	Dec. 16	5	5	Do. 5 p.c. Perp. Deb. ...	90—95	...
750,541	Aug. 9	5½	5	Southampton Ord.	57—62	...
350,000	Feb. 12	5½	5½	Swansea 5½ p.c. Red. Pref. ...	91—96	...
1,076,495	Aug. 5	5	5	Tottenham & District Ord. ...	62—67	...
338,555	,,	5	5	Do. 5 p.c. Pref.	78—83	...
453,380	Dec. 9	4	4	Do. 4 p.c. Perp. Deb. ...	76—81	...
1,247,505	May 20	4	6	U. Kingdom Gas Cor. Ord. ...	13/—15/–	...
1,085,952	Nov. 25	4½	4½	Do. 4½ p.c. 1st Cum. Pref. ...	13/6—15/6	...
772,709	,,	4	4	Do. 4 p.c. 1st Red. Cum.Pref.	13/—15/–	...
745,263	Dec. 16	4½	4½	Do. 4½ p.c. 2nd Non.Cum. Pf.	12/—14/–	...
1,200,000	Sept. 9	3½	3½	Do. 3½ p.c. Red. Deb. ...	82—87	...
380,606	Aug. 5	7	6⅜	Uxbridge, &c., 5 p.c.	80—90	...
1,371,138	July 8	3½	4	Wandsworth Consolidated ...	66—71	...
2,525,768	,,	4	4	Do. 4 p.c. Pref.	63—68	...
1,343,964	Dec. 16	5	5	Do. 5 p.c. Deb.	88—93*	...
383,745	,,	4	4	Do. 4 p.c. Deb.	75—80*	...
558,342	July 15	6	5	Watford & St. Albans Ord. ...	85—90	...
300,000	Dec. 9	3½	3½	Do. 3½ p.c. Red. Deb. ...	84—89*	...

SUPPLEMENTARY LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Dec. 26.	Rise or Fall on week
351,685	Dec. 16	5	5	Brighton, &c., 5 p.c. Perp. Deb.	88—93	...
28,700	,, 17	5½	5½	Do. 5½ p.c. Red. Deb. 1942 ...	95—100	...
415,250	,, 23	4	4	Bristol Gas Co., 4 p.c. New Deb.	83—88*	—2
140,205	July 29	7	7	Cambridge, &c., 7 p.c. Cons. 'B'	100—110	...
295,932	Aug. 19	5	5	Cheltenham, 5 p.c. Cons. Ord....	88—93	...
42,500	Dec. 16	4	4	Do. 4 p.c. Perp. Deb....	75—80	...
150,000	Aug. 12	4	4	Croydon Gas, 4 p.c. Pref. (Irr.)	65—75	...
130,000	July 1	4	4	Do. 4 p.c. Deb. ...	75—80	...
146,700	Aug. 19	5½	5½	East Surrey, 5½ p.c. Pref. 'A' ...	80—90	...
53,220	,, 19	6	6	Do. 6 p.c. Cum. Pref. ...	90—100	...
117,425	Feb. 5	8	8	East Wight, 5 p.c. Cons. Ord. ...	100—110	...
...	Aug. 19	6	4	Eastbourne, 'B' 3½ p.c....	65—75	...
239,135	Nov. 11	5	5	Gas Consolidation 'A' Ord. (£1)	13/—15/-	...
156,600	Aug. 19	5	5	Hampton C't, 5 p.c. Cons. Ord.	68—73	...
18,000	Dec. 2	7	7	Malta & Med'n., 7 p.c. 1st Pref.	55—65	...
10,845	,, 2	7½	7½	Do. 7½ p.c. 2nd Pref.	55—65	...
50,000	Aug. 19	£5 19 6	£5 4 6	Mid. South. Util., 'A' Cons. 5 p.c.	60—70	...
65,000	Aug. 12	5	5	North Middlesex, 5 p.c. Pref. ...	87—92	...
70,000	Sept. 9	5	5	Plymouth & Stone., 5 p.c. Deb.	87—92	...
76,501	July 1	4	4	Reading, 4 p.c. Perp. Deb. ...	75—80	...
74,777	Sept. 30	4	4	Romford, 4 p.c. Debs. (Reg.) ...	77—82	...
21,000	Dec. 16	5	5	Slough, 5 p.c. Perp. Deb. ...	87—92*	...
211,740	,, 17	5	5	Southampton, 5 p.c. Red. Deb.	90—95	...
363,575	July 1	5	5	Tottenham, 5 p.c. Reg. Red. Mt.	95—100	...
202,019	Oct. 14	6⅝	6⅝	Tunbridge Wells, 4 p.c. Scale ...	70—80	...
135,257	June 10	5	5	Uxbridge &c., 5 p.c. Perp. Deb.	90—95	...

PROVINCIAL EXCHANGES

					Quotations Dec. 20.	
47,756	July 26	6	5	Bath Cons.	94—98	—1½
122,577	July 22	7	6	Blyth 5 p.c. Ord.	100—105	...
1,667,250	July 15	5	5	Bristol, 5 p.c. max.	90—93	...
120,420	Dec. 16	4	4	Do. 1st 4 p.c. Deb.	92½—94½*	—1½
415,250	,,	4	4	Do. 2nd 4 p.c. Deb. ...	91—94*	—1
328,790	,,	5	5	Do. 5 p.c. Deb.	107—110*	—1
157,150	Aug. 5	6½	5	Chester 5 p.c. Ord.	98—101	...
92,500	Dec. 16	4	4	Do. 4 p.c. Pref.	79—84*	—1
36,430	,,	3½	3½	Do. 3½ p.c. Deb.	79—84*	—1
41,890	,,	4	4	Do. 4 p.c. Red. Deb. ...	93—97*	—1
542,270	Aug. 12	9	6	Derby Cons.	100—105	...
55,000	June 10	4	4	Do. 4 p.c. Deb.	96—102	...
10,000	Aug. 19	10	10	Great Grimsby 'A' Ord. ...	165—175	...
6,500	,,	10	10	Do. 'B' Ord. ...	165—175	...
79,000	,,	10	10	Do. 'C' Ord. ...	155—165	...
732,000	Aug. 26	4	4	Hartlepool G. & W. Cn. & New	61—63	...
2,167,410	Aug. 19	6	6	Liverpool 5 p.c. Ord.	97—100	...
245,500	Dec. 16	5	5	Do. 5 p.c. Red. Pref. ...	97½—100½*	...
306,083	July 15	4	4	Do. 4 p.c. Deb.	99—101	...
20,000	June 24	5	5	Long Eaton 5 p.c. Pref.	9—11	...
80,000	June 24	5	5	Do. 5 p.c. Deb.	92—97	...
2,430,267	July 29	5⅞	5	Newcastle and Gateshead Con.	16/3—17/3a	+-/3
682,856	,,	4	4	Do. 4 p.c. Pref.	75—77	+1
776,706	Dec. 27	3½	3½	Do. 3½ p.c. Deb.	80—85	...
277,285	April 24	5	5	Do. 5 p.c. Deb. '43 ...	97—102	...
274,000	July 26	5	5	Newport (Mon.) Ord.	89—93	...
13,200	Sept. 16	8⅗	7	Pontyp'l Gas & W. 10 p.c. 'A'	11½—12½	...
13,600	,,	6	5	Do. 7 p.c. 'B'	9½—10½	...
40,000	,,	5	6	Do. 7 p.c. 'C'	9½—10½	...
106,280	Aug. 5	8	10	Preston 'A' 10 p.c.	157—167	...
188,219	,,	7	7	Do. 'B' 7 p.c.	113—123	...
1,806,339	Aug. 26	6½	6½	Sheffield Cons.	118—120	...
95,000	July 8	4	4	Do. 4 p.c. Deb.	97— 99	...
332,351	Feb. 5	6	6	Sunderland 6 p.c. max. ...	107—112	...
140,778	Aug. 12	5	5	Weston-super-Mare Cons. ...	80—85	...
64,338	June 24	4	4	Do. 4 p.c. Deb.	75—85	...
33,340	,,	7½	7½	Do. 7½ p.c. Deb.	137—145	...

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